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TITLE PAGE

INVESTIGATING GLASSWARE AS A CHOICE ARCHITECTURE INTERVENTION TO REDUCE ALCOHOL CONSUMPTION

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ABSTRACT

Traditional information based health campaigns have been largely ineffectual at changing long term health behaviours. In recent years, public health researchers have been trying new approaches to change health behaviours such as changing the choice architecture of environments to nudge individuals towards healthier behaviours. The studies in this thesis set out to investigate how altering the shape and design of glassware can change consumption and other alcohol-related behaviours. First, the feasibility of manipulating glassware in naturalistic environments was investigated. I found it was possible to change the stock of glassware in pubs and it was possible to use monetary takings as a proxy for consumption. Second, there was strong evidence that shape of glassware influences the pouring accuracy of liquid volume. Pouring was more accurate at 11 data points in straight compared to curved glasses in an online task. Straight and inverted glasses resulted in more accurate pouring compared to tulip and curved glasses. Third, applying a midpoint marker to curved glassware appears to have no meaningful effect on consumption speed. However, applying two additional markers at 1/4 and 3/4 slowed consumption marginally. Last, the effect of a design feature on lager glasses known as a nucleation stamp was investigated. I found evidence that lagers in nucleated glasses were rated as more visually appealing and refreshing than lagers in non-nucleated glasses. However, there was no direct evidence that nucleation affected the consumption of lager either in terms of volume consumed or speed of consumption. Whether glassware can change consumption and other alcohol-related behaviours depends on what aspect of the glass is altered. It remains to be seen if population alcohol consumption can be reduced via glassware based interventions tested in this thesis.

DEDICATION/ACKNOWLEDGEMENTS

I would like to thank my fiancé Vicky for her unwavering love and support throughout this PhD. I couldn't have done it without her. She kept me motivated, kept me sane and kept things in perspective. She is my best friend and my greatest source of strength. Hopefully, this PhD will lead to a good life for the both of us. I would like to thank my family for their love and support. Although they are an Irish Sea away, I have always felt them pushing me to succeed. I would like to thank from the bottom of my heart, my primary supervisor Angela Attwood. She struck a perfect balance between pastoral care and pushing me to be the best scientist I can be. She knew instinctively when I needed a pat on the back or a kick up the bum. More the latter than the former I can assure you. I will be forever grateful for all the hard work she has done on my behalf, her theoretical knowledge, her attention to detail, her direction and guidance through the minefield of science and academia but above all her kind and patient nature. I think it says it all that I was more motivated and excited to do my work walking out of our weekly meetings than walking in. I would like to thank my workstream lead Olivia Maynard for her enthusiasm and advice whenever I needed it. She was never too busy to answer my queries and questions. She is an inspiration and I'll be forever grateful for her help during this PhD. I would also like to thank the rest of my supervisory team Marcus Munafo and Matt Hickman for their support and expertise. My work was immeasurably improved by their critique and sound judgement. I feel so fortunate to have undergone my training as a scientist under the stewardship of my supervisory team and in the Tobacco and Alcohol Research Group. The Group's emphasis on open science methods, transparency and honesty in pursuing scientific truth has been a joy to be embedded in. Great, fun people too! I would also like to thank the G2 crew, the Brussels massive and everyone else I shared an office with in my 3 years and all the great friends I met in Bristol. I can't remember a day when I didn't laugh.

AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

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Chapter 1: General Introduction

1.1 Alcohol statistics in the UK/World

In 2010, worldwide alcohol consumption was equal to 6.2 litres of pure alcohol consumed per person aged 15 years and older. The United Kingdom (UK) consumed more than the world average at 11.6 litres of pure alcohol per capita. In 2012, the harmful use of alcohol resulted in 3.3 million deaths, or 5.9% of all global deaths, rising from 3.7% in 2002 (World Health Organization, 2014). In the UK, alcohol accounts for 10% of the burden of disease and death, making it the third greatest lifestyle risk factor after smoking and obesity (HM Government, 2012). The excessive use of alcohol causes large disease, social and economic burdens to society. Alcohol has a high economic cost to societies with annual costs estimated at approximately €125 billion in the European Union (Anderson & Baumberg, 2006), £21 billion in the UK (HM Government, 2012) and $233.5 billion in the United States (US) (Bouchery, Harwood, Sacks, Simon, & Brewer, 2011). Alcohol is a causal factor in more than 60 diseases and conditions including a variety of cancers, cardiovascular diseases, liver cirrhosis and mental disorders (Anderson & Baumberg, 2006). Liver disease, the fifth commonest cause of death and the majority of which is due to excessive alcohol consumption, is the only major cause in the UK that continues to rise (Williams et al., 2014). The higher an individual's alcohol consumption, both in terms of volume over the lifespan and the combination of frequency of drinking and amount consumed per incident, increases the risk of these alcohol-related harms (Rehm et al., 2010; World Health Organization, 2009). Furthermore, this is not restricted to individuals with alcohol dependence. Individuals with modest levels of alcohol use within societal norms can also suffer from these harms (Brandish & Sheron, 2010). Therefore, interventions to reduce population levels of alcohol consumption are needed to deliver important public health and economic benefits.

1.2 Alcohol control strategies and interventions

This thesis is focussed on developing interventions to reduce alcohol use at the population level. Population level interventions can be more cost-effective and wide reaching than individual interventions that focus on changing individual attitudes and behaviour to alcohol (Anderson, Chisholm, & Fuhr, 2009). That is not to say that interventions at the individual level should not be part of a national strategy to reduce excessive alcohol use. Brief interventions in primary care or workplace settings are effective in reducing alcohol use, although their implementation requires more resources than population-level interventions (Anderson et al., 2009; Chisholm, Rehm, Van Ommeren, & Monteiro, 2004; Webb, Shakeshaft, Sanson-Fisher, & Havard, 2009).

Policy-based strategies such as using taxation to regulate the demand for alcoholic beverages, restricting the availability of alcohol and banning alcohol advertising are cost-effective in reducing alcohol-related harms (Anderson et al., 2009; Chisholm et al., 2004). The World Health Organisation (WHO) (World Health Organisation, 2013) has called for domestic policies to be implemented in the form of excise taxes, minimum unit pricing (MUP), banning below-cost selling and volume discounts. The majority of countries have excise taxes on alcoholic products but only a few countries have implemented other policies open to them. In terms of effectiveness, there is strong evidence for an effect of alcohol pricing on consumption. A meta-analysis of over one thousand price elasticity estimates in 112 countries found a strong, negative relationship between alcohol tax/price and consumption (Wagenaar, Salois, & Komro, 2009). Overall, it was found that a 10% increase in price resulted in a 4.4% decrease in alcohol consumption. In support, two other meta-analyses reported negative median price elasticities between 4.6% and 8.2% reduction in beer, wine and spirit consumption (Campbell & Fogarty, 2006; Gallet, 2007).

There has been increased public debate in the UK and Australia over whether to introduce MUP as a public health measure. Canada has implemented MUP and evidence suggests it has had a positive effect. Studies investigating the effect of twenty years of the policy found that a 10% increase in the minimum price of alcoholic beverages reduced consumption by 16% (Stockwell et al., 2013). MUP is also associated with a reduction in the number of deaths and hospital admissions related to alcohol (Stockwell et al., 2013; Zhao et al., 2013). A ban on below cost selling (i.e., duty plus value added tax) was implemented in the UK in 2014, which is estimated to affect 0.7% of units sold with a reduction in consumption estimated to be minimal at 0.08% or 3 units a year. A MUP of 40-50p is estimated to have approximately 40-50 times greater impact on consumption and health harms associated with alcohol than a ban on below cost selling (Brennan, Meng, Holmes, Hill-McManus, & Meier, 2014). The beneficial impact would be greater among harmful drinkers on low income because they purchase more alcohol under the MUP threshold than other socioeconomic groups (Brennan et al., 2014).

Restricting the availability of alcohol is another effective method of reducing consumption and alcohol-related harms. A systematic review found consistent evidence for a positive association between outlet density and violence, harm to others and drink-driving deaths (Chikritzhs, Catalonao, & Pascal, 2009). Another review reported that an increase in the number of days and hours people could purchase alcohol led to more consumption and harm while a reduction had the opposite effect (Anderson & Baumberg, 2006; Babor, Barbor, Caetano, & Casswell, 2003). Increasing the legal drinking age is another avenue to reduce alcohol availability. A review of 132 studies between 1960 and 1999 in the US showed that increasing the legal age from 18 to 21 can reduce youth drinking and alcohol-related harm, including road traffic accidents (Wagenaar & Toomey, 2000).

In sum, there is consistent evidence across countries supporting the effectiveness of population-level strategies such as raising the cost of alcohol and reducing availability at reducing alcohol consumption. Governments are still reluctant to implement these policies due to lobbying pressure from the alcohol industry (McCambridge, Hawkins, & Holden, 2014) and unpopularity of intrusive policies (e.g., raising taxes on alcohol products) among the general public (Diepeveen, Ling, Suhrcke, Roland, & Marteau, 2013). Alternative strategies that are more popular with the public are needed. Choice architecture interventions (CAIs) (Hollands et al., 2013) are an alternative approach to reduce population alcohol consumption that are theoretically less intrusive and more acceptable to the public.

1.3 Choice architecture overview

1.3.1 Defining choice architecture

Recent interest in choice architecture research was inspired by the popular book *Nudge* in which the authors endorse a political philosophy known as libertarian or soft paternalism. The book sets out how individuals can be nudged towards choices that are in their best interests without limiting choice. The authors define a nudge as “any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives” (Thaler & Sunstein, 2008). In the context of public health, an operational definition of CAI’s has provided come clarity. They have been defined as “interventions that involve altering properties or placement of objects or stimuli within micro-environments with the intention of changing health-related behaviour” (Hollands et al., 2013). Research into how choice architecture affects human behaviour has grown in many disparate fields such as consumer protection (Shafir, Simonson, & Tversky, 2006), public health (Blumenthal-Barby & Burroughs, 2012), environmental behaviour (Cornforth, 2009), financial decision making (Thaler & Benartzi, 2004) and development aid (Banerjee & Duflo, 2012).

1.3.2 Theory of human behaviour

For CAI’s to be effective, how people behave in environments where unhealthy behaviours occur must be broadly understood. Recent attempts to explain human behaviour tend to result in dual-process or dual-systems models (Hofmann, Friese, & Wiers, 2008; Sherman, Gawronski, & Trope, 2014; Strack & Deutsch, 2004). Such models propose two broad systems of human behaviour. One system generates behavioural decisions based on values and facts towards meeting identifiable goals through reasoned, reflective processes. The other system elicits behaviour through associative links and motivational orientations cued by external stimuli. I will refer to these two systems as reflective and automatic systems of behaviour from now on. Information processing is thought to be carried out differently in each system. The reflective system processes information in a rule-based manner that draws upon rules structured by language and logic. These rules can be learned quickly and this learning occurs with conscious awareness of steps of processing. The automatic system processes information that draws on associations structured by similarity and contiguity which are learned over a long period of time. Associations occur automatically and pre-consciously with only awareness of the result of processing (Smith & DeCoster, 2000). The reflective and automatic systems can overlap and interact resulting in any given behaviour being a complex mixture of the two.

The dominant theories of health behaviour (Ajzen, 1991; Bandura, 1998; Prochaska & Diclemente, 1983) focus on the role of the reflective system in changing behaviour and assume that engaging conscious processes (e.g., behavioural intentions, risk perceptions, etc.) will result in long-term behaviour change. Meta-analyses show that a medium-to-large change in intention results in a small change in behaviour (Cohen's d = .36) (Webb & Sheeran, 2006), and a large change in risk perception has a small effect on behaviour (Cohen's d = .23) (Sheeran, Harris, & Epton, 2011). In sum, targeting reflective processes does not appear to have a large or sustained effect on behaviour change. Therefore, there is growing interest in health and experimental psychology and public health circles to target automatic processes cued by external stimuli (Marteau, Hollands, & Fletcher, 2012; Sheeran, Gollwitzer, & Bargh, 2013). This shift in focus may result in more substantial changes in health-related behaviours. These behaviours can be influenced by interventions that are outside of the conscious awareness of participants (Maas, de Ridder, de Vet, & De Wit, 2012; Papies & Hamstra, 2010; Van Kleef, Otten, & van Trijp, 2012). Non-conscious processes by which this is possible have been investigated. One such process is implicit cognition, which refers to knowledge or cognitive processes that remain outside of a person's awareness. This has been explored in the health literature by investigating attentional bias. This is commonly looked at by modified Stroop tasks (Cox, Fadardi, & Pothos, 2006) where participants have to name the font colour of substance-related words and control words; the difference in response times or error rates between the two class of words represents the degree of attentional bias. For instance, substance-related attentional bias is directly proportional to the quantity and frequency of substance use (e.g., alcohol, cannabis and heroin) (Field & Cox, 2008). The influence of implicit attitudes on health behaviours has also been researched. Implicit attitudes are "best characterised as automatic, affective reactions from particular associations that are activated automatically when one encounters a relevant stimulus" (Gawronski & Bodenhausen, 2006). Various measurement procedures are used to ascertain implicit attitudes such as the Implicit Association Test (IAT) (Greenwald, McGhee, & Schwartz, 1998) and the Go/No-Go Task (Nosek & Banaji, 2001). These measures use response times to infer implicit feelings about a target person, object or behaviour. For instance, evidence supports the use of implicit measures of alcohol attitudes to predict alcohol use. In a review, the sample-weighted average correlation between implicit attitudes about alcohol and alcohol use was $r = .23$ (Reich, Below, & Goldman, 2010). Albeit a small effect, it appears to be consistent. Another review found an average correlation of $r = .22$ between IAT scores and alcohol and drug use (Greenwald, Poehlman, Uhlmann, & Banaji, 2009).

A new system that incorporates automatic and reflective processes is the COM-B system (Michie, van Stralen, & West, 2011). In this system, capability, opportunity and motivation (COM) interact to generate behaviour (B). Capability is defined as the individual's psychological and physical capacity to engage in an activity. It can be split into physical and psychological capability (e.g. capacity to engage in comprehension, reasoning, etc.). Opportunity is defined as the factors outside the individual that make the behaviour possible or prompt it. It can be divided into physical opportunity afforded by the environment and social opportunity granted in the cultural milieu that dictates the way we see the world (e.g. concepts that make up our language). Motivation is defined as the brain processes that energise and direct behaviour. It is composed of reflective (e.g. evaluations and plans) and automatic (e.g. emotions and impulses that arise from associative learning and/or innate dispositions) processes. The single and double-headed arrows (Figure 1) represent potential causal links between components and behaviour. The model suggests that interactions between capability, opportunity and motivation cause the performance of a behaviour.

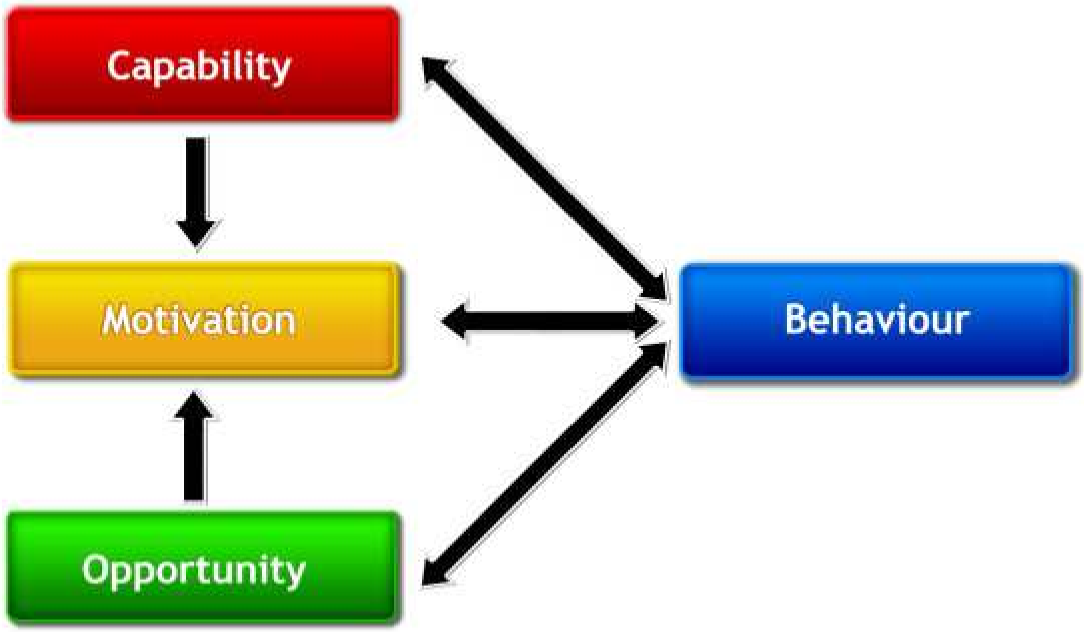

Figure 1. The COM-B system – a framework for understanding behaviour. Taken from 'The behaviour change wheel: A new method for characterising and designing behaviour change interventions' (Michie et al., 2011).

1.3.3 CAI evidence

Shaping our environments to cue certain behaviours is extremely effective, often to the detriment of our health. For example, the ready availability of foods that are packaged, presented and engineered to stimulate our automatic behavioural system has contributed to us eating more than we need (Ruhm, 2012). Current architects of micro-environments where alcohol is purchased and consumed have not considered public health as a priority. However, there has been increased interest in the public health community in recent years to redesign these environments to nudge individuals toward healthier choices. A summary and provisional typology of CAIs targeting unhealthy lifestyle behaviours has been compiled (Figure 2) from a review of the evidence base for CAIs (Hollands et al., 2013).

PROVISIONAL TYPOLOGY OF CHOICE ARCHITECTURE INTERVENTIONS IN MICRO-ENVIRONMENTS		MAPPING OF AVAILABLE EVIDENCE BY INTERVENTION TYPE AND TARGET BEHAVIOUR			
Intervention class	**Intervention type**	**Number of study reports (combining primary research and reviews)**			
		Diet 309/440=70.2%	**Physical activity** 84/440=19.1%	**Alcohol** 32/440=7.3%	**Tobacco** 15/440=3.4%
Primarily alter **properties** of objects or stimuli	**AMBIENCE** - alter aesthetic or atmospheric aspects of the surrounding environment	33	10	14	
	FUNCTIONAL DESIGN - design or adapt equipment or function of the environment	27	11	5	
	LABELLING – apply labelling or endorsement information to product or at point-of-choice	78		7	10
	PRESENTATION - alter sensory qualities or visual design of the product	21			2
	SIZING - change size or quantity of the product	66			1
Primarily alter **placement** of objects or stimuli	**AVAILABILITY** - add behavioural options within a given micro-environment	28	6		
	PROXIMITY – make behavioural options easier (or harder) to engage with, requiring reduced (or increased) effort	21	1		
Alter both **properties and placement** of objects or stimuli	**PRIMING** - place incidental cues in the environment to influence a non-conscious behavioural response	9	1	5	1
	PROMPTING – use non-personalised information to promote or raise awareness of a behaviour	26	55	1	1

Figure 2. Provisional typology of choice architecture interventions in micro-environments with the mapping of available evidence by intervention type and target behaviour. Taken from 'Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions' (Hollands et al., 2013).

Much of the evidence is concentrated on targeting dietary behaviours such as food purchasing and consumption (70.2% of study reports). A short review of this evidence will follow immediately. Interventions that altered the ambient, atmospheric or aesthetic aspects of a micro-environment such as altering the décor, brightness of lighting, music volume and tempo were reported to have an effect on eating behaviour. For example, classical music in a restaurant was associated with higher spending than both no music and pop music (North, Shilcock, & Hargreaves, 2003). Interventions that change the size of an overall package, size of a portion served or contained within an overall package or the size of an individual unit within a portion were reviewed. The majority of studies reported an effect of portion size on eating behaviour. For example, increasing the portion size of an entrée resulted in increased energy intake in a restaurant setting (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004). The majority of interventions that altered the availability of food and drink options in restaurants, cafeteria's and vending machines were found to have an effect on behaviour. For example, doubling the number of fruit choices and increasing the number of salad choices in a cafeteria were associated with a threefold increase in fruit and salad purchases (Jeffery, French, Raether, & Baxter, 1994). The majority of interventions that manipulate the proximity of behavioural options within micro-environments reported an effect on dietary behaviour. Study effects generally reflected changes in consumption, purchasing and selection of products. For example, varying the proximity of food by approximately 10 inches in a salad bar reduces food intake by 8-16% (Rozin et al., 2011). The majority of interventions that primed individuals to reduce their food intake through the placements of cues, objects or stimuli within a micro-environment were found to have an effect on behaviour. For example, adding an Italian theme to a restaurant increased the selection of pasta by customers and increased the perceived Italian ethnicity of British pasta, fish and veal (Bell, Meiselman, Pierson, & Reeve, 1994).

Fewer intervention studies were found focusing on tobacco behaviours (3.4% of studies). The majority of which investigated the effect of labelling on products or point-of-choice. For example, engaging with graphic cigarette warning labels on packs were associated with quitting, making a quit attempt or reduced smoking three months after the study (Hammond, Fong, McDonald, Cameron, & Brown, 2003). Systematic reviews have suggested that larger warnings with pictures are more effective than smaller text-only messages (Hammond, 2011). One-off studies in other intervention types such as presentation, sizing, priming and prompting made up the totality of studies targeting tobacco behaviours. For example, smoking cigarettes half the length of full-length (100 mm) cigarettes did not reduce intake of smoke in a 100 minute *ad libitum* sessions (Chait & Griffiths, 1982). Physical activity interventions constituted 19.1% of studies included in the review. The majority of interventions involved prompting certain behaviours through standardised explicit verbal, visual and/or numeric information. These were found to be broadly effective in changing behaviour. For example, posters that promote stair use encouraged shoppers of lower levels of activity to use stairs instead of escalators (Kerr, Eves, & Carroll, 2000).

The discrepancy in the amount of interventions targeting dietary behaviours and physical activity can be explained by the fact that there is a much larger range of food products and environments that researchers can intervene in compared to the area of physical activity. No obvious explanation can be posited for the difference in the number of nudge interventions targeting dietary and alcohol behaviours. Alcoholic products are just as numerous as food products and can be consumed in many of the same environments. Therefore, there is scope for many intervention types that have been concentrated on dietary behaviours to be tested on alcohol behaviours. This thesis will fill some of this evidence gap by focusing on altering an aspect of the functional design (i.e., glassware) of micro-environments where alcohol is consumed. The two most common types of interventions (accounting for over 40% of study reports) involve point-of-choice labelling and prompting. These interventions generally provided information (e.g. about the nutritional content of food, or the health benefits of using stairs) to consumers. While these individual nudges can be effective in changing health-related behaviour (Hollands et al., 2013), none to my knowledge, have been evaluated for their ability to achieve sustained behaviour change necessary to improve health long term. In the short term, a population health strategy will require the cumulative effect of multiple nudges to bring about meaningful change in behaviour. Therefore, more primary research investigating the effect of cumulative nudges on behaviour is needed followed by long term appraisal of their effects.

1.4 Choice architecture and alcohol

The modification of environments where alcohol is consumed has received some attention in the public health community. The WHO's global alcohol strategy (World Health Organisation, 2014) and the European alcohol action plan (World Health Organisation, 2012) both identify drinking environments as important settings in which to tackle alcohol-related problems. CAIs which can be embedded within micro-environments where alcohol consumption occurs (e.g., public houses and home environments) are likely to be particularly effective, given the extremely wide potential reach of such interventions.

A range of interventions has been evaluated in micro-environments where alcohol is consumed. The effect of ambience on the consumption alcohol has been studied and results appear to be mixed. The presence of music has been shown to affect alcohol drinking behaviour; male drinkers in two bars drank more beer when music was played than when it was off (Drews, Vaughn, & Anfiteatro, 1992). Structural components of music (e.g. sound level, tempo, tonality) also seem to influence alcohol consumption. Higher sound levels of music than usual in a bar was associated with the consumption of more alcoholic drinks (Guéguen, Hélène, & Jacob, 2004; Guéguen, Jacob, Le Guellec, Morineau, & Lourel, 2008). The influence of tempo of music is less clear. Increasing the tempo of music decreased the time spent consuming a drink (McElrea & Standing, 1992). In contrast, restaurant patrons spent more dollars per person on average at the bar when a slower music tempo was played (Milliman, 1986), which has been replicated (Caldwell & Hibbert, 1999). Also, it was found that the slower the tempo of country western music, the faster bar patrons consumed their drinks (Bach & Schaefer, 1979). An "arousal" hypothesis has been posited to explain these results. A high sound and tempo level of music creates a high level of arousal in the consumer which leads them to enhance their behavioural response toward the stimulus (i.e. alcohol) resulting in faster consumption. Slow tempo music leading to increased consumption would seem to contradict this, however the different metric of consumption is important. Increased consumption over an evening may be due to slow tempo leading to slowed eating leading to more time spent on the premises. A limitation of this area of research is that the effect of music cannot be isolated from other environmental cues, therefore caution is warranted. There is a lack of laboratory studies that could address this limitation. Other studies have investigated the effect of sound on people's evaluation of the taste/flavour of different alcoholic beverages. People perceive their wine in congruence with the music in their environment (e.g., wine was rated as more mellow/soft when mellow/soft music was played) (North, 2012; Spence, Velasco, & Knoeferle, 2014; Wang & Spence, 2015a). This effect has been replicated during consumption of other alcoholic drinks, including vodka (Wang & Spence, 2015b), whisky (Velasco, Jones, King, & Spence, 2013) and beer (Reinoso Carvalho, Wang, Van Ee, & Spence, 2016).

Observational research has investigated what aspects of drinking environments result in higher levels of intoxication, alcohol use and related harm. A review of the literature identified a range of physical and social factors associated with higher levels of alcohol use and related harm. Crowding, unpleasant surroundings, poor ventilation, low lighting and high noise levels were associated with aggression, violence and expectations of violence. A permissive environment (i.e., tolerance towards anti-social behaviour), drinks promotions and a focus on music and dancing were associated with higher levels of alcohol use, intoxication and aggression (Hughes et al., 2011). A subsequent review found independent associations between intoxication and use of plastic glassware, the promotion of non-alcoholic drinks (often energy drinks), poor washroom facilities and the presence of a dancefloor (Hughes et al., 2012).

Applying labelling to alcohol products is another possible CAI although evidence on their effectiveness to date is mixed. Reviews of alcohol health warnings have shown that the public awareness of health harms increase after implementation, but this does not translate to increased alcohol-related risk perceptions or reduced alcohol consumption (Stockley, 2001; Stockwell, 2006; Wilkinson et al., 2014). Additionally, a systematic review claimed that alcohol-related health warnings do elicit an intention to change drinking patterns but do not result in sustained behaviour change (Wilkinson & Room, 2009). This may be due to minimal attention paid to warning labels. Participants spend on average 7% of viewing time directed at warning labels in alcohol advertisements (Thomsen & Fulton, 2007) and on alcohol and soda containers (Kersbergen & Field, 2017). However, when attention is successfully drawn to warning labels, subsequent alcohol use of bar visitors can be reduced. Drinkers who were displayed warning labels drank less alcoholic drinks than a control group who were not exposed to the labels (Malouff, Schutte, Wiener, Brancazio, & Fish, 1993). It appears that grabbing the visual attention of drinkers is key to influencing their drinking behaviour.

Perhaps, the success of tobacco warning labels, which are larger, more graphic and alternate their messages (Borland et al., 2009), could inform alcohol warning labels going forward. However, there are differences in the risk profile in tobacco and alcohol use. The negative effects of smoking are much less disputed than those of alcohol given there is evidence that low doses of alcohol are associated with positive health outcomes (O'Keefe, Bhatti, Bajwa, DiNicolantonio, & Lavie, 2014). There is also a clear 'zero consumption' goal of tobacco control measures, which is not the message in alcohol public health interventions. Therefore, what has been successful in targeting tobacco users may not translate to alcohol consumers.

In sum, there is an increased focus on what aspects of drinking environments can be altered to reduce alcohol-related harms. Apart from experimental research on altering the ambience of premises and applying health warnings to alcohol products, there is a paucity of studies in this area. Observational research can be informative on what environmental factors are commonly associated with alcohol harms, however there is a lack of experimental research into how changing the functional design of micro-environments could reduce alcohol consumption and associated harms.

1.5 Choice architecture and glassware

Glassware is a tool used by the alcohol industry to recruit consumers, revive brands, build profits and increase consumption (Stead, Angus, Macdonald, & Bauld, 2014). The public health community has begun to target glassware attempting to reduce excessive alcohol consumption and have a positive impact on public health. It appears that changing the dimensions of glassware can influence how people interact with, perceive and consume alcoholic drinks. The shape of a glass can affect the time taken to consume an alcoholic beverage; straight glasses appear to slow consumption of lager (but not lemonade) compared to curved glasses (Attwood, Scott-Samuel, Stothart, & Munafò, 2012). There was weak evidence of a positive association in this study between the degree of error when judging the midpoint and total drinking time. This suggests that perceptual errors of glass volume may underlie the effect of glass shape on drinking speed. This points towards a relationship between accuracy of volume judgements and consumption speed.

There is also evidence that the shape of glassware affects the sensory experience of consuming wine. A study indicated that a bulbous wine glass shape, compared to 'tulip' or 'beaker' glasses, produces a higher intensity of wine odours and an increasing liking of this odour. A speculative explanation is that bulbous glasses trap odours better than the other two glass shapes (Hummel, Delwiche, Schmidt, & Hüttenbrink, 2003). Wine glasses with larger maximum diameter of bowls and larger ratios of opening diameter to maximum diameter produced the most intense aroma and colour intensity for white and red wines (Cliff, 2001).

The size of glassware is a factor that influences the pouring and consumption of alcoholic and non-alcoholic beverages. A Cochrane review found evidence that people drank more of non-alcoholic beverages when offered larger portions, packages or items of tableware compared to smaller-sized portions (Hollands et al., 2015). Research has been conducted on how the size of wine glasses affects consumption. When larger (370 ml) glasses were used in a bar/restaurant, 9.4% more wine volume was purchased and consumed compared to when standard (300 ml) glasses were used. Results were inconclusive as to whether less wine volume was purchased when smaller (250 ml) glasses were used. Portion size (175 ml) of wine was kept constant across the changes in glass size (Pechey et al., 2016). Mechanisms involved in the different patterns of consumption from different sized wine glasses seen in this study were investigated (Zupan, Pechey, Couturier, Hollands, & Marteau, 2017). A 175 ml portion of wine in a larger (370 ml) glass was consumed more slowly with shorter sip durations compared to a smaller (250 ml) glass in a laboratory setting. This was contrary to the hypothesised effect that wine would be consumed more rapidly from a larger glass. There was also no difference in the satisfaction with perceived amount and pleasure of the drinking experience between the two glasses. Although not supported in this study, a reason for increased wine consumption from larger wine glasses could be the “portion size effect”. It has been observed in food research that people perceive the amount served to them as an appropriate amount and consume less when less is served and consume more when more is served (Rolls, Roe, Meengs, & Wall, 2004). Therefore, the portion sizes we encounter on a daily basis may shape social and personal norms on what we think is appropriate to consume (Robinson et al., 2016). The larger the amount of food or size of non-alcoholic beverages, the larger bites or sips that are taken (Almiron-Roig et al., 2015; Lawless, Bender, Oman, & Pelletier, 2003). It is unclear why this was not seen with sip duration when consuming wine from a larger glass. While the mechanisms remain elusive as to why more wine is consumed from larger glasses, the alcohol industry has moved away from small wine glasses. In 2001, reported in trade circulations, licensees were advised to ‘move from 125 ml to 175 ml glasses’. Greene King saw wine sales increase by 20% in six weeks after it cleared all the 125 ml glasses out of its tenanted estate. With 175 ml as the standard and 250 ml as the large size, pubs increase both volumes and profits’ (McFarland, 2001).

Larger glassware also appears to increase the pouring of alcoholic and non-alcoholic beverages. Individuals poured 11.9% more wine into a wider glass compared to a standard 10 US fl oz glass, 9.2% more when the wine was white and 12.2% more when the glass was held in their hand compared to when it was on a table (Walker, Smarandescu, & Wansink, 2014). This seems to be true of non-alcoholic beverages when adults with shorter, wider bottles poured more water from them and consumed more of it compared to taller, narrower bottles (Wansink, Cardello, & North, 2005). This is consistent with individuals estimating the volume of the liquid within a receptacle with the height of the liquid. Further studies have showed that glass characteristics affect pouring behaviour. Similarly, US college students were asked to pour a standard (1.25 US fl oz) shot (for consumption with a mixer and without) and a standard (12 US fl oz) measure of beer. Participants over-poured standard measures for liquor for shots alone by 26%, shots for mixed drinks by 80% and beer by 25%. Participants generally poured more into containers of bigger volume capacity. Participants may be estimating proportion of liquid to container volume when making pouring judgements (White, Kraus, McCracken, & Swartzwelder, 2003). Similarly, students were asked to pour a beer, a glass of wine, shot of liquor or the amount of liquor in a mixed drink. Findings revealed that over-pouring was common and the size of glassware positively influenced the amount poured. Interestingly, glass shape did not appear to affect pouring (Kerr, Patterson, Koenen, & Greenfield, 2009). In support, participants were asked to pour 'the drink of red wine/whisky you would pour at home'. Participants had a choice between a spirit tumbler or a tall glass and poured on average 2.3 units of spirits with no meaningful difference between glass types (Gill & Donaghy, 2004).

Research has demonstrated that changing glassware in bars can result in harm reduction. An intervention replacing glassware with plastic vessels reduced injury risk and patrons felt safer in nightclubs where no glassware was present (Forsyth, 2008). This has been found in other studies where both alcohol-related assaults and nightclub accidents have been reduced by the replacement of glassware with plastic cups from drinking establishments (Luke et al., 2002; Shepherd, 1994). Another solution put forward to mitigate the risk associated with glassware is the introduction of tempered or toughened glass but even these glasses have been linked to significant injuries to both assault victims and via accidental breakages (Cole, 1994; Warburton & Shepherd, 2000).

1.6 Aims and objectives

In summary, there has been a new focus in the public health research community on carrying out research that alters environments where unhealthy behaviour choices are made. CAIs constitute a new approach to reducing population alcohol conumption that may be more acceptable to the public than established strategies. Glassware is a promising target for interventions targetting excessive alcohol use. The aim of this thesis was to carry out primary research evaluating the effectiveness of CAIs involving glassware. To evaluate the effectiveness of glassware to change drinking behaviours, studies were carried out to:

i. investigate the feasiblity of testing an intervention manipulating glass shape in a naturalistic setting;
ii. examine potential mechanisms how glass shape affects the pouring of liquid volume;
iii. evaluate a novel intervention applying volume markers to curved glassware and;
iv. investigate the effect of nucleation on the likeability and drinking rate of lager.

Chapter 2. The effect of glass shape on alcohol consumption in a naturalistic setting: a feasibility study

Disclaimer: The contents of this chapter has been published in *Pilot and Feasibility Studies*. I did not design the study, participated in the coordination of the study and drafted the manuscript.

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2.1 Introduction

Studies looking at changing drinking environments to prompt healthier alcohol-related behaviours are limited (7.3% of studies in a recent review looking at food, tobacco and alcohol-related behaviours (Hollands et al., 2013)). These studies focused on the association of altering the ambience and functional design of drinking venues and alcohol consumption. Louder music has been associated with higher alcohol consumption (Guéguen et al., 2004; Guéguen et al., 2008). Certain characteristics of drinking venues seem to be associated with harmful drinking behaviours, such as a permissive environment (i.e., 'anything goes' atmosphere, swearing, overt sexual contact, poor overall order at the premises), availability of cheap alcohol, poor cleanliness, crowding, a focus on dancing, and poor staff practice were associated with alcohol-related violence, crime and harm (i.e., injuries, accidents); although these findings were not consistent across studies (Hughes et al., 2011).

Glassware has been targeted as a potential area for intervention in bars. Research suggests that more alcohol was poured into short, wide glasses than tall, slender glasses by both students and bartenders (Wansink & Ittersum, 2005). Other research suggests that glass shape alters the rate of alcohol consumption under laboratory conditions; beer consumed from a straight glass was consumed slower compared to a curved glass (Attwood et al., 2012) potentially because of more accurate volume judgements in straight glasses. Intuitively, this slowing of drinking rate is likely to have two effects: reduced intoxication and reduced consumption overall. These perceptual and judgement biases can be used to inform glass selection by bartenders and consumers to reduce the amount of alcohol poured and consumed.

There are a number of potential challenges to carrying out a randomised controlled trial of glass shape on alcohol consumption in a naturalistic setting. These include the willingness of bars and public houses to participate in the trial, their compliance during the trial, the acceptability of the intervention by clientele of the bars, the logistical challenges of changing glassware on a regular basis and the assessment of alcohol consumption via monetary takings. I therefore conducted a feasibility study to investigate these challenges.

2.2 Methods

Study design and overview. This study was a feasibility study investigating the viability of manipulating the shape of glasses in a naturalistic setting. The study took place in three public houses over two weekends (Friday to Saturday nights, inclusive). Determining the feasibility of the study was the primary outcome measure and monetary takings was the secondary outcome which provided an indirect measure of alcohol consumption. Monetary takings data was collected to estimate the effect of glass shape on consumption. This is one of the criteria for to assess progression to a full trial. It should be noted that the study was not powered to detect a definitive effect. The exchange of glassware with the public houses was made the week before the first weekend and midweek between weekends. Types of glasses that we intended the public houses to use were counterbalanced over the two weekends and between the public houses, although the actual allocation differed due to some public houses opting to use their own glassware on some nights (see Table 1).

Table 1. Planned and actual glass conditions in the three public houses over the two study weekends.

	Weekend 1		Weekend 2	
	Planned	Actual	Planned	Actual
Pub 1	Curved	Normal glass range*	Straight	Straight
Pub 2	Curved	Curved	Straight	Straight
Pub 3	Straight	Straight	Curved	Normal glass range*

Curved and straight refer to the shape of experimenter supplied glassware. * indicates where the public house used their normal range of glassware.

Ethics approval for the study was obtained from the Faculty of Science Ethics Committee at the University of Bristol (reference number: 2502146682). The study was conducted in accordance with the Declaration of Helsinki (2013) principles.

Study sites. Three public houses owned by Dawkins Ales located in Bristol, United Kingdom, took part in the study over the course of two weekends in April 2014. The three public houses were run by individual landlords, and were relatively small, with a capacity of 25-75 people.

Materials. Straight-sided and curved pint and half-pint glasses were delivered to the public houses by the experimenters. The pint and half-pint curved glasses (Figure 3A) were Tokyo style glasses designed and supplied by Sahm, whereas the straight (Figure 3B) pint and half pint glasses were "highball" glasses, designed and supplied by Arcoroc Professional and Pasabahce respectively. Alcoholic beverages were supplied by the public houses as part of their usual trade.

A *B*

Figure 3. Curved (A) and straight (B) glasses used.

Procedure. The owner of Dawkins Ales was identified as running several local public houses, and the purpose of the study was explained to him. He agreed to introduce the study team to public houses that formed part of the Dawkins Ales group, and encourage them to support the study. Through this introduction, the study team explained the study to individual landlords, who made the final decision whether or not to participate. They were informed of the study design and the logistics involved with glass delivery and collection. They were asked if monetary takings for the study weekends could be used as the outcome measure if confidentiality was assured. All landlords and the pubs owner agreed and gave their final agreement for their public house to participate in the study. They were also informed of an unrelated experiment investigating the effects of drinking alcohol on ratings of attractiveness that the experimenters wanted to carry out in their public houses a month after the feasibility study, and all landlords agreed to this request.

Glasses were delivered to each of the three public houses by the experimenters during the week before the first weekend and were changed during the following week (i.e., before the second weekend). Public house landlords were requested to serve all beer/cider from the supplied glasses unless patrons explicitly requested another glass. At the end of each weekend, total monetary takings (excluding takings for food) for each of the three public houses were obtained from the landlords, from a till print-out. At the end of the second weekend, glasses were removed from the public houses and original glasses were restocked.

Informal feedback from the brewer and landlords was obtained by two experimenters after completion of the feasibility study but before the attractiveness experiment. It was a face-to-face discussion, rather than a formal qualitative interview, and was not audio recorded, although notes were taken. Specific questions were asked regarding the study logistics and how these could have been improved, the suitability of the incentive structure, what would encourage them to participate in future studies, and the experience of customers during the trial. After these topics were covered, there was a free-form discussion. The feedback represented the landlord's experience of the study and supplemented what the experimenters learned from the rest of the trial.

Feasibility analysis. Criteria for assessing the progression of this intervention to a full trial were evaluated in appropriate areas of focus proposed (Bowen et al., 2009) which are listed below:

- Acceptability: How targeted individuals and those involved in implementing the study react to the intervention?
- Demand: Demand for the intervention by gathering data on estimated use or by documenting the use of the intervention in a defined population or setting.
- Implementation: Concerns the extent, likelihood and manner in which the intervention can be fully implemented as planned and proposed.
- Practicality: The extent to which an intervention can be delivered when resources, time, and commitment are constrained.
- Adaptation: How can the contents or procedures of an intervention be changed to be appropriate to a new setting or population?
- Integration: What level of system change is needed to implement an intervention into an existing infrastructure or programme?

Statistical analysis. Monetary takings data from three public houses were recorded for straight glass weekends and curved glass weekends. The difference in average takings across the straight and curved glass weekends was assessed using a paired-samples *t*-test. Mean difference and 95% confidence intervals (CI) were calculated based on difference scores between takings from straight glass weekends and curved glass weekends, which were then converted into percentage change. Absolute amounts were also reported.

To investigate if monetary takings are an accurate proxy for alcohol consumption, data were obtained from a public house not involved in the feasibility study over a two-week period in January 2015. Monetary takings for three beverage categories (beer/cider, wine, and spirits) were extracted from itemised till print-outs. Units of alcohol per beverage were calculated by obtaining alcohol by volume (ABV) percentages and volume amounts from the public houses' drinks list. Separate Pearson product-moment correlations were calculated to assess the relationship between units of alcohol sold and monetary takings for beer/cider (N {number of brands} = 19), spirits (N = 24) and wine (N = 30).

2.3 Results

Acceptability. Communication with one landlord broke down during the study and he was not willing to participate on Weekend Two, although he still supplied monetary takings data for that weekend. The storage space for glassware was very limited in this public house, and the normal glassware range had to be stored off-site for Weekend One of the study. This resulted in a laborious process of boxing all of his glassware. Although assistance was provided by the study team, this was felt to be a source of disruption by the landlord. Also, some of his regular clientele expressed dissatisfaction with the new glassware.

This feasibility study was run as part of a two-study collaboration with the public houses. The other study was an unrelated experiment investigating the effects of alcohol consumption on ratings of attractiveness. This experiment was run in the same establishments, but was conducted one month later. Critically, unlike the attractiveness study, the feasibility study was not publicised, so as not to distort the behaviour of customers at the participating public houses. The quid pro quo of granting the public houses' publicity through local and university media to both obtain a healthy number of participants for the other study and temporarily increase their custom proved effective in obtaining and maintaining their support for the feasibility study.

Demand. Based on feedback from landlords, a small number of patrons were unhappy with the new glassware, and requested their normal glass. These requests were honoured. However, the majority of customers during the trial accepted the new glassware.

Implementation. The logistics of delivering and collecting glassware were negotiated with each landlord. One public house required experimenters to store their glassware off site during the study. The dishwasher in one public house was too small to wash the experimenter's curved full pint glasses and could not use them, so the public house used their standard glass range instead on Weekend One (see Table 1).

Practicality. Monetary takings were a practical way of measuring alcohol consumption without disruption to normal trade. The landlords were forthcoming with the monetary takings shortly after the weekends when the study took place. The information supplied by the public houses included monetary amounts for all sales (excluding food) over the study weekends. There were varied opening times for each of the three public houses; however, common, overlapping opening times of 5 pm to 11 pm were used when obtaining data on monetary takings. The experimenters' curved glasses were not used in two public houses (see Table 1). Critically the intervention (straight) glasses were used by all three public houses. The comparison between straight glasses and the landlord's standard glass range was deemed valid (as our comparison is with usual practice) for the purposes of the feasibility study. The difference in monetary takings was estimated using a paired-samples *t*-test, which indicated that takings were reduced by 24% (95% CI: 77% reduction to 29% increase) for the weekends when alcohol was served in straight glasses compared to the weekends when alcohol was served in curved glasses (including pub's own glassware range on two weekends).

Pearson product-moment correlations were used to investigate if monetary takings are an accurate proxy for alcohol consumption. Results provided strong statistical evidence for a positive correlation between units of alcohol sold and monetary takings for each beverage category (beer/cider: $r\{17\} = .996$, $p \leq .001$, Figure 4; spirits: $r\{22\} = .986$, $p \leq .001$; wine: $r\{28\} = .986$, $p \leq .001$, Figure 5).

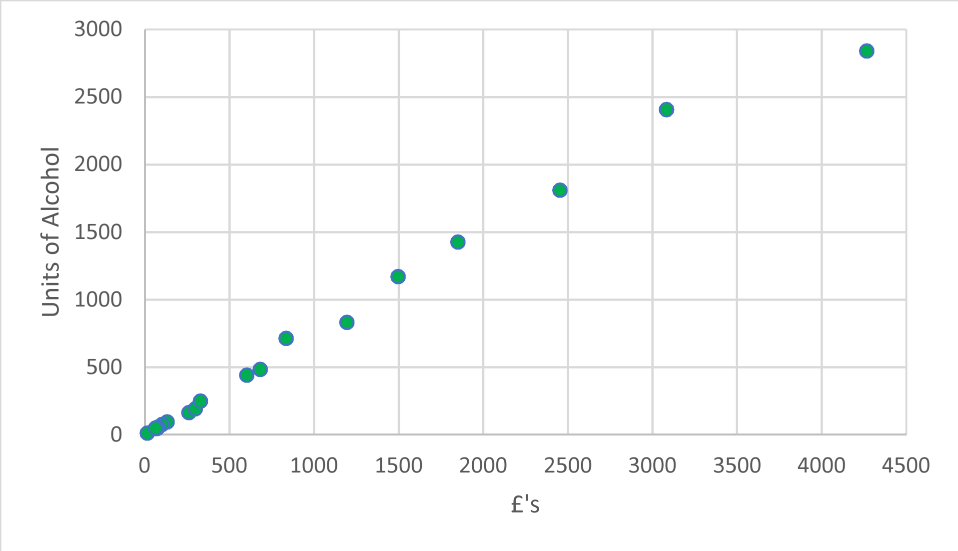

Figure 4. *Scatterplot of units of alcohol sold in beer/cider in a two-week period plotted against the money spent purchasing the beer/cider. Each data point represents a brand of beer/cider.*

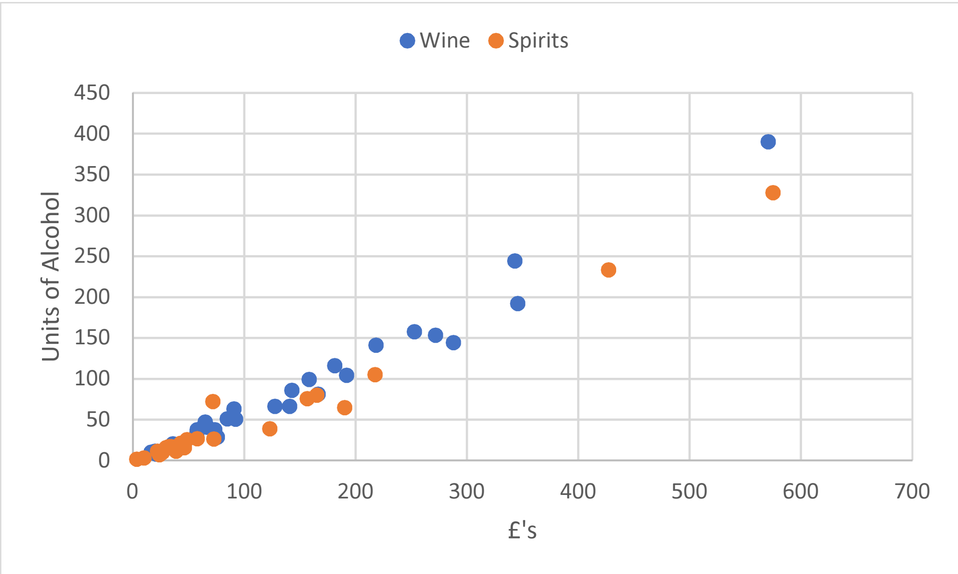

Figure 5. *Scatterplot of units of alcohol sold in a two-week period in wine and spirits plotted against the money spent purchasing the wine and spirits. Each data point represents a brand of wine/spirit.*

Integration. The introduction of new glassware was integrated into two public houses' normal trade successfully with appropriate planning and communication. As described above, one landlord felt that exchanging glassware was disruptive to his normal business. A convenient time for delivery and collection of glassware had to be negotiated with each public house. The glassware supplied by experimenters did not contain any nucleation, and it was noted by landlords during post-study feedback that glasses need to be nucleated for lager and cider beverages to better integrate into the public houses' normal trade.

A sample size calculation for a future full trial was carried out based on the results of the paired-samples *t*-test. A sample size of 30 public houses and bars would be sufficient to detect a moderate to strong difference in monetary takings of at least 0.6 standard deviations with 90% power at the 5% significance level (assuming a correlation of $r = 0.65$ in takings between the two periods) (Machin, Campbell, Fayers, & Pinol, 1997). The standard deviation is difficult to estimate, but in this study, it was £155 per night across the three pubs. On this basis, a future trial would be able to detect a reduction of £93 per night. Assuming an average price of £3.80 per pint, this is equivalent to approximately 24 pints sold per night, which is equivalent to approximately 62 units of alcohol (assuming a strength of 4.5% ABV).

2.4 Discussion

Our results indicate that, with detailed planning and good communication with public house staff, naturalistic studies of this nature can be run effectively. Communication with individual proprietors of public houses was essential to keep them engaged with the study. However, some important lessons were also learned. Communication with one landlord broke down during the study and he was not willing to participate further. The dishwasher in one public house was too small to wash the experimenter's curved full pint glasses and could not use them, so the public house used their standard glass range instead (see Table 1). The majority of customers during the trial accepted the newly shaped glassware which was determined by if they consumed their drink from the experimenter supplied glassware and didn't request a different glass. Although some did express dissatisfaction mainly due to the lack of nucleation on the experimenter supplied glassware. The collection of monetary takings data from each landlord was straightforward and was carried out by an experimenter after the first weekend and at the end of the study. Overall, the brewer and landlords were satisfied with how the study was carried out and there is potential for further collaboration.

The breakdown of communication with one landlord resulted in him not participating on Weekend Two of the study. Experimenters were relying on the brewer to maintain good communication with his landlord regarding the purpose and importance of the study. Good communication is needed between the study team and each individual landlord directly to foster loyalty to any future study. Experimenters need to engage each landlord with the study and explain incentives to them effectively, so that potential benefits to landlords are clear. Being a small public house with regular clientele, some of them expressing dissatisfaction with the new glassware, may have been an important factor in his decision not to participate on Weekend Two.

The consensus from the post-study feedback with the brewer and landlords was that no reimbursement for involvement was necessary except for being supplied with new glasses at the end of the study. However, in my opinion the brewer and landlords would have been less keen to participate if there was not a second event that provided publicity and increased custom for their public houses. If this type of incentive is not feasible for a particular study, it may need to be replaced to encourage participation from public houses in the future. This could include new glassware provided free of charge, and/or the public houses' participation could be publicised via blogs and press releases after data collection has concluded. The optimal method of compensation should be discussed with landlords. If any intervention serves to reduce monetary takings it would seem ethical and appropriate to offer some financial reimbursement for this, given the competitive nature of the industry (particularly when participating public houses are part of a relatively small local brewer, as in this case). If a commitment to offer financial reimbursement for loss of earnings was made before a future trial, this may alleviate the concern of landlords of maintaining equivalency of earnings.

A public house's dishwasher and shelving units should be inspected to ensure they are fit for purpose before participation in any future study. Storing one public house's original stock of glasses off-site during the study was not an issue; however, if more public houses are involved in future studies this may be difficult. Where possible, public houses should be able to store all glassware on site. If this is not possible, contingency plans should be put in place. The storage space of each public house should be assessed at an early stage in future studies. If glasses are going to be given to public houses as an incentive to participate in future studies, this may be less of an issue. Assistance was provided by one experimenter to help stock and wash the glasses which was appreciated by landlords. Further assistance from the study team may be needed in future studies so that transfers of glassware are less disruptive.

There was a reduction in takings on weekends when straight glasses were used in the three public houses compared to when curved glasses were used. Although the mean difference (24% reduction) was imprecise with wide confidence intervals, it is worth noting that it was in the same direction as a previous laboratory study investigating the effect of glass shape on the drinking rate of an alcoholic beverage (Attwood et al., 2012). The wide confidence interval (95% CI: 77% reduction to 29% increase) suggests a large variability between the three public houses and these results should be considered with caution, as the study was not designed to support hypothesis testing. The main purpose in collecting the results was to inform the design of a future full trial. Dawkins Ales, which owns all three public houses, requested that monetary takings not be made public, due to the commercial sensitivity of this information; therefore reporting aggregated results was not possible. However, if there was a larger number of participating public houses involved, as would be the case in future studies, reporting aggregate amounts of monetary takings would be possible with appropriate approval, because it would be harder to infer the takings of individual public houses in this situation.

Results from the post-study investigation into the accuracy of monetary takings as a proxy for alcohol consumption showed consistently strong, positive correlations between units of alcohol sold and monetary takings for different beverage categories. This suggests that monetary takings are an accurate proxy for alcohol consumption based on these data. A limitation of the data used was the inability to calculate the amount of alcohol sold on a daily basis within the two-week window; therefore a correlation between units of alcohol consumed and total monetary takings could not be calculated. A standard measure of alcohol units can be compared across sites to evaluate alcohol use in different conditions (straight vs curved) provided that data on units of alcohol in beverages of interest are available to researchers. In future studies, landlords should be requested to send their takings (preferably broken down by beverage type) on a weekly/periodic basis to experimenters via email or a collection of them could also be arranged. Many modern tills have the capability to break down purchases into different drink types and this should be utilised in future studies. This would allow sales of soft drinks to be accurately separated from alcoholic drinks and changes in the sales of soft drinks to be monitored over the duration of a future trial. Another option is to take an inventory of alcohol (e.g., number of kegs, bottles, etc.) although public houses may be reluctant to give such detailed information. If this is the case, monetary takings can be used effectively as a proxy for alcohol consumption. A balance must be kept between accuracy of alcohol consumption and maintaining a naturalistic drinking environment.

Customers taking their custom elsewhere is a potential alternative explanation for the reduction in alcohol consumption during the study when public houses were stocked with straight glasses. This would appear to be a reduction in consumption in a trial, but would not in fact reflect a reduction in individual-level consumption. This would be difficult to monitor in a real-world environment. However, the low percentage of patrons objecting to the straight glasses in this trial suggests that the level of customer dissatisfaction may not deter public houses from participating especially with the agreement to compensate for any lost profits during a trial.

Studies of this nature can be run on a low research budget. Data collection costs can be kept to a minimum at each study site, since the intervention can be delivered within public houses and bars as part of their routine trade. Post-study feedback suggested that two public houses found the intervention practical to implement. The public house who withdrew from the study after Weekend One found aspects of the study impractical to implement; namely disruption caused by changing glassware and customer dissatisfaction with experimenter-supplied glassware. Sensitivity to these types of issues need to be paramount when assessing the practicality of future study designs.

Glassware supplied by the study team did not include any branding, nucleation or volume labelling, which are all common features on glassware used in on-trade premises. As the intervention (unbranded) glassware was not used on two of the weekends, it is possible that these aesthetic factors may have influenced alcohol consumption, rather than the structural properties of the glass. This is a point to consider when trying to integrate into the normal trade of a public house, since they may be reluctant to stock glasses without these design features for a longer period, in which case some elements (e.g., nucleation and volume labelling) may have to be applied to all glasses. It should be considered that some consumers who expressed dissatisfaction with experimenter-supplied glassware in this study may have done so due to the lack of these common features of modern glassware being present. Considerations around glass design (e.g., branding, nucleation) should be responsive to these views.

If the intervention is shown to be effective in reducing alcohol consumption, it would need to be implemented legislatively, due to the demand to implement the intervention voluntarily by public houses predicted to be low. In the United Kingdom, the 2003 Licensing Act (Licensing Act, 2003) afforded powers to local licensing authorities to issue alcohol licences and enforce the conditions of the licence in their area. This change has made licensing more local and flexible to the needs of the local community. It has also made the process more responsive to emerging evidence. Alcohol licensing conditions are not subject to the same regulatory framework as, for example, treatments within the National Health Service, meaning that evidence of efficacy can be directly translated into policy much more rapidly. It is conceivable that the evidence from a future study could be implemented in local authority licensing policies within 2-5 years of the end of the study (depending on where in the licensing cycle the evidence becomes available). If results show that straight glasses reduce consumption, a local licensing authority would be able to add a requirement to stock straight glasses to its “menu” of licensing conditions which it can require premises to accept in order to be granted a license. When an existing premise applies to vary its license, a responsible authority can demand certain conditions be met in order for the variation to be granted. Any person or responsible authority (e.g., the local police force) can also apply to the licensing authority for a review of an existing license, with the aim of amending its conditions. If evidence shows that straight glasses reduce consumption, the police or local licensing authority may deem it worthwhile to require that more straight glasses be stocked in existing licensed premises to bring about a reduction in crime and public disorder associated with alcohol misuse (Collins, 1981; HM Government, 2007; Plant, Plant, & Thornton, 2002). Critically, the intervention is one which, if mandated would not impose additional direct costs on public houses and bars, since the glassware that constitutes the intervention is no more expensive than existing glassware. Moreover, since glassware is replaced regularly (due to breakages etc.) any transition would have minimal impact.

A limitation of the study was that data on the usual business of the public houses were not collected. There is a possibility that the weekends were not representative of normal business. Testing on multiple sites over various timescales is needed to generate the evidence for a robust effect. Another limitation of the study was that we explicitly targeted on-trade consumption of alcohol, but individuals are increasingly consuming alcohol at home (British Medical Association, 2008). However, if consumption can be lowered in the on-trade market, this would still have a significant impact on public health. Also, the hypothesised impact of straight glasses are not exclusive to on-license premises and there is potential for a similar effect in slowing drinking rate in the home.

Further studies should expand in scope to include other public houses over longer periods of time to get a more comprehensive picture of the effect of glass shape on alcohol intake. We suggest that the indirect measurement of alcohol consumption, using monetary takings from itemised till receipts for alcoholic beverages, may be an appropriate outcome measure in future studies. On the basis of our experience in this experiment and the sample size calculation for a future trial, we estimate a six-month data collection period in 30 public houses and bars would be sufficient to detect a difference in monetary takings. Collaborating with larger chains of public houses in the future would present unique challenges. The increased number of staff working in these establishments would involve putting more trust in management to communicate effectively with their employees. More glassware would be required, and a more substantial logistical effort needed to transport and stock these glasses. Extra personnel would be needed to carry this out. It may be more difficult to get larger chains of public houses involved in public health research on their premises, given that stocking straight glasses would impact on their business long-term. It may be more fruitful to engage with public houses with a community ethos rather than a high volume business model. Other key stakeholders, including local authorities and relevant trade associations, have also pledged their support for future studies, and this should aid recruitment efforts. To avoid attrition in future studies, open communication should be maintained with each individual landlord so that any issues and concerns can be dealt with as soon as they arise. A periodic meeting between staff of public houses and experimenters during future studies is advisable. Nevertheless, study designs should incorporate the possibility of attrition due to participating public houses dropping out over the course of the study. Advantages such as publicity and new glassware at low or no cost to their public house should be emphasised to foster loyalty to future studies.

In conclusion, our results suggest that it is feasible to manipulate the type of glasses in a public house provided there is detailed planning and clear communication with landlords. It is also feasible to monitor alcohol intake of customers via monetary takings with no disruption to normal trade. Brewery owners and public house landlords will participate and allow studies in their establishments given the appropriate incentive structure. The logistical challenges encountered during this trial and proposed solutions will inform other study teams aiming to carry out naturalistic studies in public houses. It is pivotal to establish what types of study designs can be executed and what interventions can be tested in public houses. The efficacy of potential interventions need to be evaluated in 'real world' environments in order to persuade local licensing bodies to implement emerging evidence into local licensing policy. Choice architecture interventions – such as modifying glass shape – can contribute to population-level reductions in excessive alcohol consumption.

Misjudgements of volume in differently shaped glassware in previous research (Attwood et al., 2012) that may be responsible for the slowing of alcohol consumption which was tentatively supported in this chapter may also be present when people pour alcoholic beverages. Therefore, in the next chapter, I will explore the effect of glass shape on the pouring accuracy of liquid volume in an online and cafe environment.

Chapter 3. The effect of glass shape on the pouring accuracy of liquid volume

Disclaimer: In Study 2, I did not take the lead in designing the experiment but did contribute. I did not code the online task but took ownership of the study from data analysis onward.

3.1 Introduction

Glassware appears to influence how people pour alcoholic drinks. Research has shown that more alcohol was poured into short, wide glasses compared to tall, slender glasses by both students and bartenders when asked to pour a standard measure (Wansink & Ittersum, 2005). Similarly, people pour more into wider wine glasses than narrower wine glasses (Walker et al., 2014). A mechanism to explain this difference is that individuals tend to focus their pouring attention on the height the liquid reaches and insufficiently compensate for the width of the glass (Wansink & Van Ittersum, 2003). However, in other work looking at the effect of glass size and shape on wine volume judgements, results were broadly consistent with people using the relative fullness of glasses as the salient dimension to judge volume of wine (i.e., the less full the glass, the less volume was perceived; the more full the glass, the more volume was perceived) (Pechey et al., 2015). The relative fullness of liquid within glassware appears to have been the most salient feature when judging volume in this study. This may be due to the wine glasses being relatively similar in height. In studies where height was the most salient dimension when judging volume, the differences in the height of glassware was more pronounced.

Initial laboratory (Attwood et al., 2012) and naturalistic (Troy, Maynard, Hickman, Attwood, & Munafò, 2015) research have suggested that glassware that promotes more accurate volume judgements can lead to slower consumption of alcoholic beverages. In support, a study applying volume information to glassware in an attempt to improve the accuracy of volume perceptions also slowed alcohol consumption (Troy et al., 2017). More accurate pouring may also result in slower consumption in line with this research.

In summary, perceptual biases involved in volume judgements may affect the pouring of liquid volume. Different shapes of glassware may counteract or exacerbate these biases. It is important to investigate what glass shapes encourage more accurate pouring because it may influence consumption of alcoholic beverages in the home which is on the rise in the UK (British Medical Association, 2008). Therefore, in Study 2, I investigated the effect of glass shape on the pouring of liquid in an online environment (adjusting volume in the online task will be described as “pouring” for the sake of consistency). Using a computerised task, participants were asked to pour liquid to eleven volume percentages in straight and curved glasses. If glasses of a certain shape can promote more accurate pouring, they could have a knock-on effect of slowing and/or reducing alcohol consumption. Hypotheses are as follows:

H_1: Pouring is more accurate in the straight glass condition compared to curved glass condition.

H_0: No difference in pouring between the straight and curved glass conditions.

In Study 3, I investigated pouring accuracy in a cafe environment using glasses of increased volume capacity of varying shapes. Hypotheses are as follows:

H_1: Pouring is more accurate in the straight glass condition compared to other glass conditions.

H_0: No difference in pouring between the straight glass condition and other glass conditions.

3.2 Study 2

3.2.1 Methods

Design and overview. This online study measured the accuracy of 'pouring' liquid to a designated volume, using a within-subjects design with factors of glass shape (straight, curved) and requested percentage fullness (10, 20, 25, 30, 40, 50, 60, 70, 75, 80, 90%). Ethics approval was obtained from the Faculty of Science Research Ethics Committee at the University of Bristol (reference: 310108288). The study was conducted in accordance with the Declaration of Helsinki (2013) principles. Informed consent was obtained from all participants.

Participants. Participants (*n* = 211) aged 18 or over were recruited through Amazon's Mechanical Turk website (https://www.mturk.com). Two hundred and ten participants were based in the USA, one was based in the UK. No additional inclusion or exclusion criteria was stipulated in recruitment besides being over 18 and having a Mechanical Turk account. Information on the alcohol use of participants was not requested as there is no evidence to suggest that levels of alcohol use influences volume perception.

Materials. The curved glass was a pilsner style glass purchased at a local supermarket (Figure 6A). This specific glass was chosen to improve the ecological validity of the study because is commonly used in on-licence premises and it is used with bottled products which the consumer can pour themselves. The straight glass was a "highball" style glass supplied by Paşabahçe (Figure 6B). Glass stimuli were generated from sets of photographs taken of these two 12 UK fl oz (341 ml) glasses using a digital camera (Canon Digital IXUS 70). Each set was a sequence of 61 photographs ranging from an empty (0) to a full (60) glass with liquid added in 60 equal weight increments.

A B

Figure 6. Curved (A) and straight (B) glasses used both poured to 50% capacity.

Procedure. Participants were presented with an information page about the study followed by a page requesting informed consent. After consenting, they were asked to enter demographic characteristics (age and sex) for descriptive purposes only rather than in expectation of age or sex differences. They were then presented on screen with either an empty straight or curved glass (see Figure 6) and were asked to "pour" designated volume amounts by manipulating the amount of liquid in the glass via their mouse, scroll pad or touch screen. Each participant completed 22 trials (2 glasses × 11 {10, 20, 25, 30, 40, 50, 60, 70, 75, 80, 90%} volume judgements: glass empty at trial start) in random order. On completion of all trials, they were debriefed and given contact details of the experimenter if they wanted to enquire further. The task took approximately seven minutes and participants were reimbursed $1 for their time. Participants needed to be logged in to the Mechanical Turk website with their individual username to complete the experiment and they were restricted from carrying out the task multiple times.

Statistical analysis. Raw data were converted from scores of 0-60 to millilitres. Data were inspected for outliers in all 22 trials using boxplots, and were removed if residing three times the interquartile range (IQR) below quartile 1 or above quartile 3. Mean poured volume was calculated by averaging poured amounts across all non-outlying participant data. Curve estimations were carried out on the straight and curved glass data to determine if the data followed a linear or non-linear trajectory. Curve estimation regression models were generated for the straight and curved glass data and F statistic was used to estimate the model of best fit. Analyses were conducted using IBM SPSS (SPSS Statistics Software

Release 23, IBM Corporation). In the absence of a clear basis for estimating a likely effect size, no sample size calculation was carried out prior to data collection. However, the eventual sample size provided 80% power at an alpha level of 5% to detect an effect size of *dz* = 0.19 for the difference in pouring between straight and curved glasses. This effect size was calculated by reducing each participant's data to the mean difference between their responses in each condition and dividing it by the standard deviation of the mean differences.

3.2.2 Results

Participants (*n* = 211; 103 female) were on average 33 years (*SD* = 12, range = 18 to 65). The number of participants tested was arrived at by letting the task run over one night. The task took on average 6:48 mins (range = 2:19 to 9:28). One participant's data was excluded for all trials as their responses suggested they did not carry out the experiment as instructed. The pattern of their data suggested that their understanding of instructions was inverted (i.e., low requested percentage volumes were given responses near the full end of the spectrum) and 41% of their responses resided outside the outlier removal criteria. Otherwise, outlying participant data points were removed at the trial level as the pattern of their data suggested they completed the task as instructed. Outliers removed comprised 0.01% of responses.

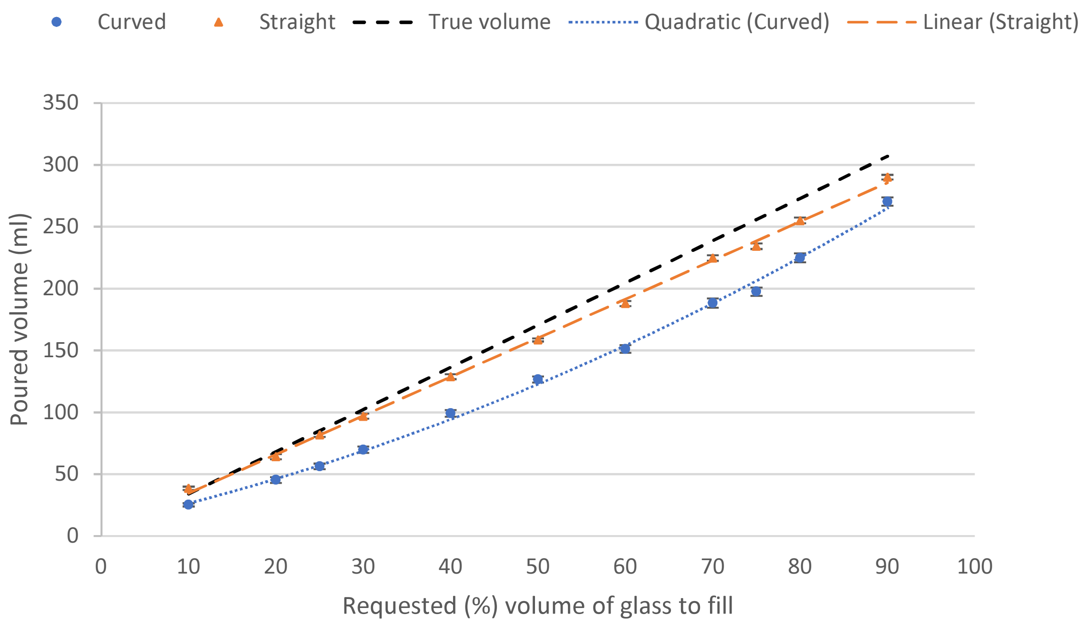

Figure 7. Volume poured in millilitres at each requested amount in straight and curved glasses. Error bars represent 95% confidence intervals.

Participants generally under-poured in straight and curved glasses compared to requested amounts (Figure 7). Participants under-poured in curved glasses at all requested amounts tested compared to straight glasses. Confidence intervals for data points for straight glasses resided outside confidence intervals for data points from curved glasses suggesting a clear difference in responses. Curve estimations suggested that a linear regression equation best described average data at each requested amount from straight glasses ($F_{1,9} = 62.58$, $p < 0.001$; volume poured in ml = 3.16 + {3.14*requested volume percentage}), while a quadratic regression equation best described average data from curved glasses ($F_{2,9} = 50.66$, $p < 0.001$; volume poured in ml = 9.54 + {1.55*requested volume percentage} + {.01*requested volume percentage^2}).

3.2.3 Discussion

Participants under-poured in curved glasses at all points tested compared to straight glasses. This may be explained by individuals using the height of liquid in a glass as a proxy for volume. The height liquid reaches in the curved glass and the volume of the liquid changes in a non-linear relationship. However, in straight glasses, the height of the liquid and the volume of the liquid change in a direct, linear relationship resulting in participants pouring more accurately by possibly monitoring the height the liquid reaches in the glass. The next step is to investigate if pouring behaviour is similar in an offline environment. Therefore, I investigated pouring accuracy in a cafe environment using glasses of increased volume capacity of varying shapes.

3.3 Study 3

3.3.1 Methods

Study design and overview. This study investigated the pouring accuracy of liquid volume in different shaped glasses, using a within-subject design with one factor of glass shape (straight, curved, tulip, inverted). Pint sized glasses were used to make the study more ecologically valid. The tulip shaped glass was included as it is commonly used in licensed premises and in homes. The inverted glass was included to investigate the effect of a glass shape that distributes volume differently than the tulip or curved glass on pouring accuracy. The protocol was pre-registered prior to data collection on the Open Science Framework (https://osf.io/dbq8q/). Ethics approval was obtained from the Faculty of Science Research Ethics Committee at the University of Bristol (reference: 14061638781). The study was conducted in accordance with the Declaration of Helsinki (2013) principles. Written informed consent was obtained from all participants.

Participants. Participants (n = 96) aged 18 or over were recruited opportunistically from the predominantly staff and student population in the café in the Experimental Psychology building in the University of Bristol.

Materials. Four pint glasses (volume: 568 ml) were used (Figure 8). The straight glass was a Geo "highball" style glass supplied and designed by Arcoroc Professional (Figure 8A). The curved glass was a Tokyo style glass supplied and designed by Sahm (Figure 8B). The tulip glass was supplied by Paşabahçe (Figure 8C). The inverted glass was a San Miquel branded stemmed glass supplied by http://www.drinkstuff.com (Figure 8D). A jug filled with water was required for pouring and a 5 ml denominated measuring cylinder was required for measuring. A laptop was used to record volume measurements.

A B C D

Figure 8. Straight (A), curved (B), tulip (C) and inverted (D) pint glasses.

Procedure. Passers-by and people sitting in the café were asked if they would like to participate in an experiment and were given the opportunity to read a study information sheet and ask questions. After written informed consent was obtained, participants were asked demographic information (age and sex), how many units of alcohol they drink a week and if they drink beer. The order in which four glasses were presented included all 24 permutations and an equal number of participants were randomly assigned (using random number assignment software: www.randomizer.org) to each order. Participants were asked to fill glasses presented to them (ordered per randomisation) with water to half the volume the glass can hold. After each pouring, the glass was removed from participant's sight to avoid comparisons between pourings. When pourings were made in all four glasses, each amount was poured in turn into a measuring cylinder and recorded on an Excel spreadsheet. After testing, participants had the option of entering their email address into a different spreadsheet to enter a draw for a £20 Amazon gift card. Participants were then debriefed as to the purpose of the experiment and final written consent was obtained.

Statistical analysis. Outliers were inspected via boxplot and were removed if they were three times the IQR below quartile 1 or above quartile 3. Error scores were generated by calculating the differences between the volumes poured into empty glasses and the midpoint volume (284 ml). A one-way repeated measures ANOVA was carried out to determine whether pourings differed in the four glasses. Bonferroni-corrected post-hoc *t* tests were carried out to compare pourings in the straight glass with pourings in the other glasses. These tests were carried out to test my hypothesis which was based on previous work suggesting straight glasses result in the most accurate perception of volume (Attwood et al., 2012) and pouring of volume (Study 2). The Bonferroni correction was applied to counteract the problem of multiple comparisons and a p-value of 0.016 was established for significance testing. Analyses were conducted using IBM SPSS (SPSS Statistics Software Release 23, IBM Corporation).

I calculated that a sample size of 96 participants would provide 80% power at an alpha level of 5% to detect an effect size of $dz = 0.29$. This effect size was estimated based on exploratory work, which suggested an effect size of $dz = 1.37$ for the difference in average midpoint pouring in straight versus curved glasses. I chose a conservative estimate of likely effect size, on the assumption that the effect size observed in our exploratory work was likely to be inflated. The sample size of 96 was also chosen to aid in study design. This sample size would allow four glasses to be presented in all 24 order permutations to the 96 participants. This counterbalancing would reduce potential order effects. Comparisons between tulip versus straight and inverted versus straight glasses were exploratory in so far as this study may not be adequately powered to detect a difference in pourings between these glass pairs.

3.3.2 Results

Participants (n = 96; 62 female) were on average 23 years old (SD = 9, range = 18 to 63) and drank an average of 11 units of alcohol a week (SD = 13, range = 0 to 80), with 59% reporting that they consumed beer. No outlying data were detected.

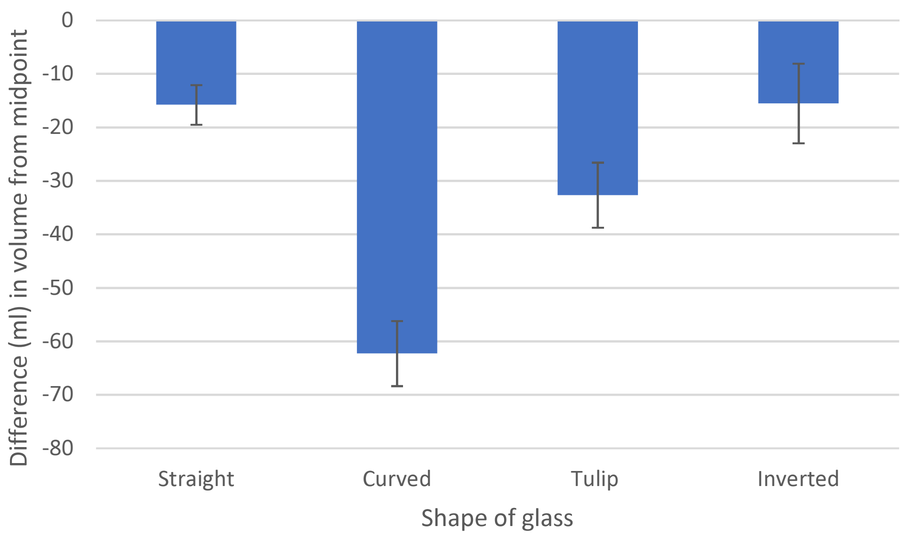

Figure 9. Mean differences in volume poured in millilitres (poured volume in empty glass minus midpoint volume). Error bars represent 95% confidence intervals.

Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of glass, $\chi^2_5 = 44.99$, $p < 0.001$. This means that variances of the differences between all combinations of the within-subjects conditions (i.e. glass conditions) were not equal. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .76$) in order to adjust for a potentially inflated F-ratio. A one-way repeated measures ANOVA suggested strong evidence for a main effect of glass on pourings ($F_{2.29, 217.31} = 75.51$, $p < 0.001$, partial $\eta^2 = .44$). Bonferroni-corrected post-hoc t tests indicated that pourings differed in curved ($t_{217.31} = 11.86$, $p < 0.001$, $dz = 1.51$) and tulip glasses ($t_{217.31} = 5.29$, $p < 0.001$, $dz = 0.59$) compared to straight glasses suggesting less liquid was poured into tulip and curved glasses compared to straight glasses. There was no evidence to suggest that pourings in inverted glasses ($t_{217.31} = .06$, $p = .95$, $dz = 0.01$) differed from pourings in straight glasses.

3.3.3 Discussion

Participants under-poured in tulip and curved glasses compared to straight and inverted glasses. Participants using the height of liquid within glasses as a proxy for volume estimations can broadly explain these findings. Height and volume of liquid changes in a direct, linear relationship in straight glasses while shaped glassware follows a non-linear relationship. Results suggest the more height and volume deviate from a direct, linear relationship in shaped glasses, the more inaccurate pouring becomes. This would explain why pourings in curved glasses were the most inaccurate because the difference in diameter from the narrowest to the widest point of curved glasses was greater than other glasses resulting in an increased overall deviation from a direct, linear relationship.

3.4 General Discussion

Pourings were closer to the requested amounts (eleven points in Study 2, midpoint in Study 3) in straight glasses compared to curved glasses (Studies 2 and 3) and tulip glasses (Study 3), consistent with our hypothesis. One potential explanation for this is that participants used the height of the liquid as the most salient dimension to estimate volume. Straight glasses may promote more accurate pourings because the height of liquid within the glass and the volume of the liquid changes in a direct, linear relationship.

Interestingly, pourings in the inverted glass were similar in accuracy to straight glasses in Study 3. A potential explanation is that the skew of volume distribution within glasses affects volume pourings. The inverted glass skews the distribution of volume towards the bottom of the glass which results in the true volume midpoint residing below half the height of the glass. Therefore, if participants were aiming to pour liquid to half the height of a glass as a proxy for volume, they would pour more volume into this glass. However, this was not the case as participants still under poured compared to true midpoint. A reason for this could be the influence of the stem. If participants used the height of liquid as a proxy for volume, they may have used the total height of the glass from the bottom of the stem to make their halfway volume judgement. This would lead participants to pour less into the glass that if no stem was present. The effect of the skew of volume distribution would also explain why curved glasses resulted in the most underestimated pourings as volume distribution is skewed towards the top of the glass. If participants were aiming to pour liquid to half the height of this glass, they would under pour volume more so than in the other glasses tested.

Findings from Study 2 suggest that the higher the requested volume is, the more inaccurate (i.e., underestimation) volume pourings are in both glasses with underestimations increasing up to the 75% point. This supports other research that suggests that proportions greater than 50% tend to be underestimated (Hollands & Dyre, 2000; Varey, Mellers, & Birnbaum, 1990). However, accuracy improved in both glasses but more so in the curved glass as liquid neared 100% (i.e., full glass) in contradiction of the same research that suggests that underestimations increase as the proportion nears 100%. This could be due to a different heuristic being employed by participants when actively pouring volume to different proportions as opposed to static judgements of proportions. That heuristic could be using the top of the glass as a reference point when making volume judgements above the 75% mark. Participants may use the top and bottom of glassware to aid in their volume judgements. The accuracy of pouring in the curved glass in Study 2 improved at points closer to the top and bottom of the glass compared to points closer to the 50%. The same can be said for straight glasses but to a lesser degree because the improvement in accuracy was not as noticeable. The improvement of pouring accuracy over 75% in straight glasses suggests that although a linear regression equation best described the straight glass data, the data was not perfectly linear.

It is possible the pouring biases seen in these studies may translate to changes in consumption of alcoholic beverages. Evidence from both studies suggest that straight glasses promote accurate pouring which may lead to more accurate titration by consumers resulting in slower consumption. Further research should investigate the relationship between pouring in straight glasses and speed of consumption of an alcoholic beverage. If this can be shown, it would strengthen the case for promoting the use of straight glassware as an effective public health intervention. However, it may be the case that the tulip and curved glasses that resulted in the under-pouring of alcoholic beverages may also be an effective health promotion intervention. Given that the current trend in the UK is towards more people drinking at home (British Medical Association, 2008), it would seem important to determine which glassware would be effective in slowing alcohol consumption. If certain glasses were found to reduce the amount of alcohol consumption or slow drinking rates, the use of these glasses could be incentivised. Alcoholic beverages could be sold at a lower cost in on-license premises in glassware that promotes more responsible drinking and glassware could be given to consumers with the sale of alcohol from off-licenses to change drinking behaviour in the home. Further work should expand this line of research to wine glasses given that wine is more commonly poured by consumers than beer.

Some limitations should be considered when interpreting these results. First, in Study 2, participants used their own computer, tablet or mobile device to complete the study and these varied in terms of display quality and size which may have differentially affected performance on the task. Second, Study 2 was carried out in an online environment on two dimensional stimuli and performance of participants may not generalise to real world environments. Third, performance in both studies may not generalise to the pouring of alcoholic beverages given that previous research has found differing effects of volume perception on the consumption of alcoholic and non-alcoholic beverages (Attwood et al., 2012). Fourth, in Study 3, the inverted glass was branded and had a stem (see Figure 8D) which was inconsistent with other glasses. Implications drawn from pourings in this glass should be treated with caution. Finally, the implications of the findings of these studies is limited by the lack of evidence that perceptual biases can influence alcohol consumption. Some preliminary studies (Attwood et al., 2012; Troy et al., 2015) suggest it is possible, however robust replications are needed to strengthen the evidence that correcting volume perceptual biases can result in the reduction of alcohol consumption in real world settings.

Straight and inverted glasses appear to result in more accurate pourings than curved and tulip glasses. The heuristic of using the height of liquid as the salient dimension to judge volume can broadly explain the pattern of results seen in both studies. An additional factor that may be influencing pourings, in conjunction with the aforementioned heuristic, is the skew of volume distribution within glassware. Given the increased inaccuracy of pouring in tulip and curved glasses seen in this chapter and previous work (Attwood et al., 2012) showing a positive association between the degree of error in volume judgements and drinking rate, an intervention targeting shaped glassware with the aim of slowing drinking rate by improving the accuracy of volume judgements would seem important. Therefore, the next chapter will investigate the effect of glass markings on drinking rate in social alcohol consumers.

Chapter 4. The effect of glass markings on drinking rate and drinking topography in social alcohol consumers

Disclaimer: The contents of this chapter has been published in *The European Journal of Public Health*. I planned and coordinated the studies, collected and analysed data and drafted the manuscript.

Citation: Troy, D. M., Attwood, A. S., Maynard, O. M., Scott-Samuel, N. E., Hickman, M., Marteau, T. M., & Munafò, M. R. (2017). Effect of glass markings on drinking rate in social alcohol drinkers. *The European Journal of Public Health, 27*(2), 352-356.

4.1 Introduction

Research has suggested that volume perceptions have an influence on the consumption of alcoholic beverages. In a study on glass shape (Attwood et al., 2012); beer (but not lemonade) was consumed slower from a straight glass compared to a curved glass. It is unclear why the effect was not seen in soft drinks, but one possibility is that there is a categorical difference whereby volume perceptions are used to titrate drinking rate in alcoholic beverages but not in non-alcoholic beverages. Another finding in the study was greater degrees of error in judging the half-way point were present when curved glasses were presented in a computerised task compared to straight glasses and there was a trend towards a positive association between the degree of error when judging the half-way point and total drinking time (with the caveat that the computerised task and drinking were carried out separately). This suggests that inaccuracies in volume judgements are greater when changes in height and volume of liquid are not directly proportional and this may lead to faster drinking speed and/or greater overall intake. People also tend to estimate that tall, slender glasses hold more liquid than wide glasses of the same volume (Piaget, 1969; Raghubir & Krishna, 1999). This may positively influence actual consumption volume while negatively influencing the perceived consumption volume.

Providing volume information on glassware may mitigate volume misperceptions and slow the consumption of alcoholic beverages. Supplying individuals with visual cues to inform their consumptive behaviour has not been researched in relation to alcohol, however it has shown promise in other areas. Food researchers have used plates containing portion size information to induce greater weight loss in obese patients compared to usual care with plates without portion size information (Kesman, Ebbert, Harris, & Schroeder, 2011; Pedersen, Kang, & Kline, 2007). Also, providing individuals with real-time feedback on their consumption behaviour can have an impact. Research involving obese young people using a portable computerised device that weighed the meal plate and compared their rate of food intake to a predetermined eating rate prescribed by a therapist and gave corrective feedback when deviating from this rate, reported a reduction in BMI after 12 months and a lower mean meal size than the control group (Ford et al., 2010).

These studies investigated whether volume information in the form of glass markings on curved glasses alters the time taken to consume an alcoholic beverage. In Study 4, a yellow tape was applied to midpoint of a curved glass. In addition, I investigated a potential dose effect of alcohol by including a lager strength factor. Hypotheses were as follows:

H_1: Drinking times would be slower in the marked glass compared to the unmarked glass.

H_0: No difference in drinking times between the two glasses.

In Study 5, the beer strength factor was removed and the volume markings were increased to three (i.e., 1/4, 1/2 & 3/4) and the volume information provided was more quantitative in nature (i.e., fractions written on the glass). Hypotheses were as follows:

H_1: Drinking times would be slower in the marked glass compared to the unmarked glass.

H_0: No difference in drinking times between the two glasses.

4.2 Study 4

4.2.1 Methods

Design and overview. The study design was a 2 × 2 between-subjects model with one factor of glass type (unmarked, marked) and one factor of lager strength (low, standard). Group allocation was randomised with the constraint that groups contained equal numbers of male and female participants and equal number of participants per group. Data were captured using video analysis and the dependent variable was total drinking time. During the study session, subjective measures of alcohol craving and mood were taken to assess any changes during the course of the study session. Ethics approval was obtained from the Faculty of Science Research Ethics Committee at the University of Bristol (reference: 310108288). The study was conducted according to the revised Declaration of Helsinki (2000) and Good Clinical Practice guidelines (5^{th} revision). Written informed consent was obtained from all participants.

Participants. Social alcohol drinkers who reported consuming between 10 and 50 Units/week for males or between 5 and 35 Units/week for females were recruited from the staff and students of the University of Bristol and from the general population by means of poster and flyer advertisements, and word-of-mouth. Participants were required to be in good psychological and physical health, aged between 18 and 40 years, weigh more than 50 kilogram (kg) if female, more than 60 kg if male and not currently taking any psychiatric medication. Exclusion criteria included current use of illicit substances (excluding cannabis) and a strong family history of alcoholism (defined as at least one first-degree relative or two or more second degree relatives) and not drinking/liking lager. Eligibility was ascertained on these variables by self-report. Participants were asked to abstain from alcohol consumption for 12 hours prior to the test session, and were only enrolled onto the study if they provided a zero-breath alcohol reading at the start of the session. Participants were reimbursed £7 or awarded course credit, as appropriate, at the end of the study.

Materials. Alcoholic beverages used were low strength (Bière des Moulins™, 3.8% ABV) and standard strength (St. Cervois™ 4.8% ABV) lager. All participants consumed their allocated drink from a curved beer glass (volume: 12 UK fl oz) as used in a previous study (Attwood et al., 2012). One glass had the midpoint marked with a band of yellow tape (Figure 10). The other glass remained unmarked.

Figure 10. Marked glass used in Study 4. Volume: 12 UK fl oz.

The questionnaire measures comprised the Alcohol Use Disorders Identification Test (AUDIT) (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993) and the Alcohol Urges Questionnaire (AUQ) (Bohn, Krahn, & Staehler, 1995). The AUDIT is a 10-item screening tool that was developed by the World Health Organisation to identify harmful or hazardous drinking behaviour. Scores of 0-7 are generally considered low-risk, while scores of 8-14 are considered hazardous and scores of 15 or over are considered harmful. The AUDIT shows good internal consistency as a single factor when used in college students (Cronbach's α = 0.82) (Shields, Guttmannova, & Caruso, 2004). The AUQ is an 8-item state measure that assesses current urges to consume an alcoholic beverage. Visual analogue scales (VAS) from 0-100 of mood (happiness, drowsiness, depression, anxiety, energy, irritability) and alcohol craving were also administered. The AUQ scores, mood and alcohol craving VASs were collected in order to ascertain whether any effects were driven by differences in urges to consume alcohol and/or differences in mood/alcohol craving.

Procedure. Experimental sessions lasted approximately 30-45 minutes and all testing took place between 12:00 and 18:00 hours. Upon arrival at their session, participants were given an opportunity to read the information sheet and ask questions before providing written informed consent. Participants were told that the study examined the effects of alcohol consumption on word search performance, in order to disguise the primary outcome measure, which if disclosed may have affected natural drinking behaviour. Participants were screened to ensure that they met the inclusion criteria, and provided a breath sample to test for alcohol in their system at the time of testing.

For the drinking session, participants received 12 UK fl oz (i.e., a full glass) of lager (either low or standard strength in an unmarked or marked glass as per randomisation). Lagers were chilled prior to serving, were opened and poured immediately prior to consumption in order to ensure that carbonation was consistent across participants. Baseline ratings of self-report measures of alcohol use (AUDIT), alcohol craving (AUQ, VAS) and mood (VASs) were administered. Participants were then given their beverage and were told that they should consume all of it at their own pace whilst watching a nature documentary (Earth: The Journey of a Lifetime, BBC Worldwide 2008). The experimenter started the film (at the same point for all participants) and left the room. The drinking session was recorded using a video camera (Hitachi Hybrid Camcorder DZHS500E). When participants had finished their beverage, the experimenter returned and presented participants with a word search task in which they were instructed to find as many words as possible in four minutes. This was intended to disguise the nature of the study, and these data were not analysed. Upon completion of this task, measures of alcohol craving (AUQ, VAS) and mood (VASs) were administered again. At the end of the session participants were informed that debriefing information would follow via email at the end of the study, and were reimbursed.

Statistical analysis. The video recordings were viewed by one researcher, and total drink time (i.e., time from initiation of first sip to end of last sip) was extracted. To assess video analysis reliability of the primary outcome measure (total drinking time), 20% of video files were chosen at random and analysed by a second independent rater, and the inter-rater reliability calculated. Total drinking time outliers were identified using boxplots, and defined as 1.5 times the IQR above quartile 3 or below quartile 1. Three outliers were removed using this criterion. We identified outliers in order to thereby capture a more natural range of drinking times as has been carried out in other *ad libitum* drinking studies (Schlauch, Christensen, Derrick, Crane, & Collins, 2015; Weafer & Fillmore, 2008).

Total drinking time data were analysed using multiple regression with glass (unmarked, marked) and lager strength (low, standard) as predictors and an interaction term of glass markings and lager strength. For the analysis of the AUQ and VAS data, linear regressions were carried out with glass markings (unmarked, marked) as predictor. Analyses were conducted using IBM SPSS (SPSS Statistics Software: Release 21. IBM Corporation).

A previous study (Attwood et al., 2012) found an effect size of d = 0.91 when measuring the difference in drinking times between straight and curved glasses. In order to be conservative in predicting the effect size we would find in this study, we calculated that a sample size of one hundred and fifty-eight would be required to provide 80% power at an alpha level of 5% in order to detect an effect size of d = 0.45 (equivalent to a slowing in drinking rate in the marked glass of 2 minutes). One hundred and sixty participants were recruited to allow equal allocation to the four experimental conditions.

The data that form the basis of the results presented here are available from the University of Bristol Research Data Repository (http://data.bris.ac.uk/data/), doi: 10.5523/bris.gujajy0f45po11lz1dln554f4.

4.2.2 Results

Participants (n = 159; 80 female) were on average 22 years (SD = 4, range = 18-39), had a Body Mass Index (BMI) of 23 (SD = 3, range = 18-39), and had an AUDIT score of 10 (SD = 4, range = 2-27). Participant characteristics are detailed in Table 2. One male was randomised to the marked/low condition in error and one extra female was recruited in error and randomised to the marked/standard condition. Data from one male in the unmarked/low condition was unusable due to video recording malfunction (giving a final sample of n = 159 prior to outlier removal). An age value for one participant was not recorded during data collection. One missing questionnaire response was inserted based on the median of the sample for that specific question.

Table 2. Characteristics of participants.

	Marked/Standard (n = 39)	Unmarked/Standard (n = 40)	Marked/Low (n = 41)	Unmarked/Low (n = 39)
Sex (female)	21 (54%)	20 (50%)	20 (49%)	20 (51%)
Age (years)	21 (3)	22 (4)	22 (4)	21 (3)
BMI (kg / m^2)	22 (4)	22 (3)	23 (3)	22 (2)
AUDIT	10 (4)	10 (4)	9 (4)	10 (3)

Standard deviation is shown in parentheses for continuous measures. Abbreviations: BMI = Body Mass Index. kg = kilogram. m = metre. AUDIT = Alcohol Use Disorders Identification Test.

Total drinking time. There was no evidence of an interaction between glass markings and lager strength when outliers (n = 3) were removed (mean difference = 1.68, 95% CI -0.95, 4.32; p = 0.21) or in the full sample (mean difference = 0.88, 95% CI = -2.31, 4.07, p = 0.59) and the interaction term was not included in subsequent analyses. When outliers (n = 3) were removed, there was no evidence that glass markings (mean difference = 0.42, 95% CI -0.90, 1.74; p = 0.53) or lager strength (mean difference = -0.55, 95% CI -1.87, 0.77; p = 0.41) predicted total drinking time. These results did not change meaningfully when the total sample was included (glass markings: mean difference = 0.45, 95% CI -1.14, 2.04, p = 0.58; lager strength: mean difference = -0.94, 95% CI -2.53, 0.65 p = 0.25). Removing lager strength, results were not altered meaningfully (Table 3).

Table 3. Effect of glass markings on total drinking time (min:sec/0.6).

	Mean drinking time				
	Marked	Unmarked	Mean difference	95% CI	p-value
Full sample (n = 159)	10.37	9.90	0.47	-1.12, 2.06	0.562
Outliers excluded (n = 156)	9.98	9.55	0.43	-0.89, 1.75	0.523

Total drinking time in low and standard strength lagers. To explore the effect of lager strength on total drinking time more thoroughly, analyses were stratified by lager strength. There was no evidence that glass markings were associated with total drinking time in low (ps > 0.66) or standard strength lagers (ps > 0.17, Table 4).

Table 4. Effect of glass markings on total drinking time in low and standard strength lagers (min:sec/0.6).

	Mean drinking time				
	Marked	Unmarked	Mean difference	95% CI	p-value
Low Strength Lager					
Full sample (n = 80)	10.62	10.60	0.01	-2.53, 2.56	0.992
Outliers excluded (n = 78)	9.84	10.26	-0.42	-2.35, 1.50	0.664
Standard Strength Lager					
Full sample (n = 79)	10.12	9.22	0.90	-1.06, 2.85	0.365
Outliers excluded (n = 78)	10.12	8.86	1.26	-0.57, 3.10	0.175

Alcohol craving and mood. There was no evidence that glass markings were associated with post-consumption alcohol craving (AUQ, VAS) or mood (VAS) (Table 5).

Table 5. Effect of glass markings on post-drinking alcohol craving and mood in low and standard strength lagers.

		Adjusted for baseline		
		Mean difference	95% CI	*p*-value
Full sample (n = 159)	AUQ	0.002	-0.26, 0.26	.985
	Happiness	-0.87	-4.05, 2.31	.589
	Drowsiness	-1.45	-7.22, 4.32	.621
	Depression	-2.28	-5.21, 0.66	.127
	Anxiety	-3.42	-7.48, 0.64	.098
	Energy	-0.29	-5.35, 4.77	.911
	Irritability	-2.64	-6.67, 1.39	.198
	Alcohol craving	1.08	-4.01, 6.16	.677
Outliers excluded (n = 156)	AUQ	-0.01	-0.27, 0.26	.956
	Happiness	-0.60	-3.82, 2.63	.716
	Drowsiness	-1.61	-7.49, 4.27	.590
	Depression	-2.41	-5.39, 0.58	.113
	Anxiety	-3.05	-7.11, 1.01	.140
	Energy	0.20	-4.95, 5.36	.938

	Irritability	-2.76	-6.86, 1.35	.186
	Alcohol craving	1.32	-3.86, 6.49	.616

Abbreviations: AUQ = Alcohol Urges Questionnaire.

Reliability analysis. The ratings of total drinking time of the two raters were strongly and positively correlated, single measures intraclass correlation (31) = .99, $p < 0.001$, indicating a high level of inter-rater reliability.

4.2.3 Discussion

These results did not provide evidence of an interaction between glass markings and lager strength, or that glass markings or lager strength influenced total drinking time. There was no evidence that glass markings had an effect on drinking times of low or standard strength lagers. Two hypothesised possibilities as to why glass markings did not slow drinking times of alcoholic beverages were considered. One was the possibility that the midpoint marking was not sufficiently detailed enough (i.e., no quantitative volume information) to alter drinking times and one marking was not adequate to influence drinking behaviour. I therefore conducted a second experiment to investigate whether more detailed volume information on curved glasses, with markings at 1/4, 1/2 and 3/4 volume points, would slow total drinking time.

4.3 Study 5

4.3.1 Methods

Design and overview. This was a human laboratory study with a between-subjects design with one factor of glass (unmarked, marked). As there was no statistical evidence to suggest lager strength was associated with total drinking time in Study 4, this condition was not included in this study. Ethics approval was granted by the Faculty of Science Research Ethics Committee at the University of Bristol (reference: 25091410961) and the study was conducted in accordance with the principles of the Declaration of Helsinki (2013) and Good Clinical Practice guidelines (6th revision). Written informed consent was obtained from all participants. Protocol was registered at http://osf.io/946q2 prior to data collection.

Participants. Identical criteria were used to select participants as in Study 4 with an additional exclusion criterion of not having taken part in Study 4.

Materials. Glasses of the same size and shape as Study 4 were used, but with different volume markings (Figure 11) consisting of black adhesive stickers at 1/4, 1/2 & 3/4 volume points. Lager used was 5% ABV Grolsch™.

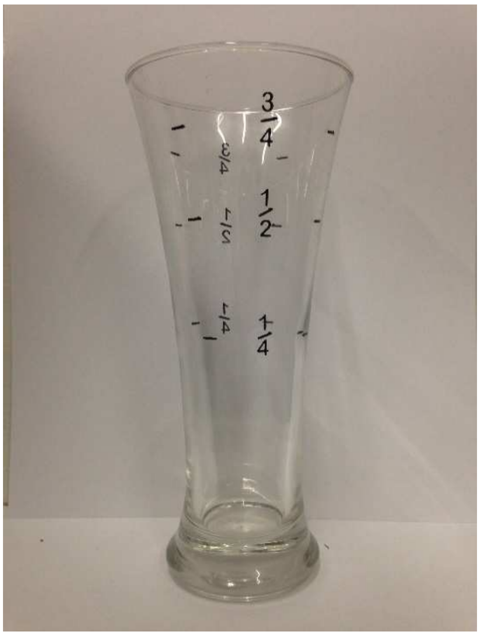

Figure 11. Marked glass used in Study 5. Volume: 12 UK fl oz.

Mood VASs were replaced by the Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988) questionnaire. The alcohol craving VAS from Study 4 was not administered as it was felt the AUQ sufficiently captured a participant's alcohol craving. All other measures were identical to Study 4.

Procedure. The procedure for this study was identical to Study 4, except the required period of abstaining from alcohol prior to the study was increased to 24 hours to avoid potential hangover effects.

Statistical analysis. Video recording of participants was identical to Study 4. In this study, additional topography measures were extracted, including sip duration (i.e. time spent sipping), interval duration (i.e., time between sips), and number of sips taken, using a specifically-designed MATLAB script (MATLAB and Statistics Toolbox: Release 2013a. Mathworks, Inc.). This programme involved pressing a button each time a sip was initiated (defined as liquid touching lips) and when the sip ended (defined as liquid leaving lips). This enabled secondary analysis of more detailed drink pattern information, which may inform future research and interventions. To assess video analysis reliability of total drinking time and topography measures, 20% of video files were chosen at random and analysed by a second independent rater, and the inter-rater reliability calculated.

Total drinking time data were analysed using linear regressions with glass (unmarked, marked) as predictor. Sip duration, interval duration and number of sips were also analysed using linear regressions with glass (unmarked, marked) as predictor. For the analysis of the AUQ and PANAS data, linear regressions were carried out with glass (unmarked, marked) as predictor. Data were analysed by linear regressions instead of independent *t*-tests (as stated in the pre-registered protocol) in order to communicate the differences in drinking times to the reader more effectively. Analyses were conducted using IBM SPSS (SPSS Statistics Software Release 21, IBM Corporation). The sample size calculation and outlier detection were the same as for Study 4.

The data that form the basis of the results presented here are available from the University of Bristol Research Data Repository (http://data.bris.ac.uk/data/), doi: 10.5523/bris.9p8s50hw70x61kgxr bunjesj5.

4.3.2 Results

Participants (n = 160; 50% female) were on average 23 years (SD = 4, range 18 to 40), had a BMI of 23 (SD = 3, range = 17-36), and had an AUDIT score of 10 (SD = 4, range = 3 to 22) which is above the cut-off for hazardous drinking (>8). Participant characteristics are detailed in Table 6. One missing questionnaire response was inserted based on the median of the population for that specific question. Four outliers were removed using the same exclusion criterion as Study 4.

Table 6. Characteristics of participants.

	Marked (n = 80)	Unmarked (n = 80)
Sex (female)	40 (50%)	40 (50%)
Age (years)	20 (3)	22 (4)
BMI (kg / m^2)	23 (3)	23 (3)
AUDIT	10 (3)	10 (4)

Standard deviation is shown in parentheses for continuous measures. BMI = Body Mass Index. AUDIT = Alcohol Use Disorders Identification Test.

Total drinking time. There was weak statistical evidence that glass markings may be associated with total drinking time (mean difference = 1.24, 95% CI -0.11, 2.59; p = .072, Table 7), when outliers (n = 4) were removed, reflecting longer drinking times in marked glasses compared to unmarked glasses.

Table 7. Effect of glass markings on total drinking time (min:sec/0.6).

	Mean drinking time				
	Marked	Unmarked	Mean difference	95% CI	*p*-value
Full sample (n = 160)	10.49	9.83	0.67	-0.91, 2.25	0.405
Outliers excluded (n = 156)	10.34	9.11	1.24	-0.11, 2.58	0.072

Drinking topography. There was weak statistical evidence that glass markings may be associated with interval duration (mean difference = 1.27, 95% CI -0.06, 2.61; p = .062, Table 8) when outliers were removed, reflecting longer interval durations in marked glasses compared to unmarked glasses. There was no evidence that glass markings were associated with sip duration or number of sips.

Table 8. Effect of glass markings on sip duration, interval duration & number of sips.

	Mean difference	95% CI	*p*-value
Sip Duration			
Full sample (n = 160)	-0.03	-0.10, 0.05	0.477
Outliers excluded (n = 156)	-0.03	-0.10, 0.04	0.349
Interval Duration			
Full sample (n = 160)	0.69	-0.87, 2.25	0.382
Outliers excluded (n = 156)	1.27	-0.06, 2.61	0.062
Number of Sips			
Full sample (n = 160)	-0.06	-2.31, 2.19	0.956
Outliers excluded (n = 156)	-0.20	-2.27, 1.86	0.846

Alcohol craving and mood. There was no evidence that glass markings were associated with post-consumption alcohol craving for AUQ data or PANAS measures of positive or negative affect (Table 9).

Table 9. Effect of glass markings on post-drinking alcohol craving and mood.

		Adjusted for baseline		
		Mean difference	95% CI	p-value
Full sample (n = 160)	AUQ	0.20	-0.06, 0.45	.128
	Positive affect	0.35	-0.90, 1.59	.583
	Negative affect	-0.05	-0.42, 0.33	.809
Outliers excluded (n = 156)	AUQ	0.19	-0.07, 0.45	.151
	Positive affect	0.26	-0.99, 1.51	.679
	Negative affect	-0.04	-0.42, 0.34	.840

AUQ = Alcohol Urges Questionnaire.

Reliability analysis. Ratings of all drinking measures carried out by two raters were strongly and positively correlated, single measures intraclass correlation *rs* > .96, *ps* < 0.001, indicating a high level of inter-rater reliability.

Meta-analysis of studies 1 and 2. When outliers were removed, there was weak statistical evidence that glass markings were associated with drinking time when data was combined from both studies (mean difference 0.83, 95% CI -0.11, 1.77, *p* = .082; Table 10), reflecting longer drinking times in the marked glass group compared to the unmarked glass group.

Table 10. Effect of glass markings on total drinking time in Studies 4 and 5 (min:sec/0.6).

	Mean drinking time				
	Marked	Unmarked	Mean difference	95% CI	*p*-value
Full sample (n = 319)	10.43	9.86	0.57	-0.55, 1.68	0.316
Outliers excluded (n = 312)	10.16	9.33	0.83	-0.11, 1.77	0.082

4.3.3 Discussion

The results of Study 5 provide weak evidence that detailed glass markings influence total drinking times, with slower drinking times in marked glasses compared to unmarked glasses. However, evidence was only observed for this when outliers were removed, so these results should be interpreted with caution. The glass markings may have assisted participants in their volume judgements between sips as there was weak evidence of longer interval durations in marked glasses compared to unmarked glasses.

4.4 General Discussion

Data indicate that providing implicit midpoint volume information alone doesn't influence the drinking time of an alcoholic beverage, however providing markings at 1/4, 1/2 and 3/4 points explicitly denoting the volume amount has a modest influence on the drinking time of an alcoholic beverage. Specifically, when outliers were removed, there was weak statistical evidence that lager was consumed slower from glasses with 1/4, 1/2, & 3/4 volume markings than from unmarked glasses. The data from Study 5 tentatively supports our initial hypothesis that accurate volume information would result in a slower rate of consumption of an alcoholic beverage. This is qualified by the fact that the design and how volume information is communicated appear to be important. When the data from the two studies was meta-analysed, there was weak statistical evidence suggesting an influence of volume information on drinking time after removing outliers. These effects do not appear to be driven by differences in mood or alcohol craving as there was no statistical evidence for an effect of glass type on differences over time in these measures over the course of either study. There appears to be a pattern, based on the two studies reported here, that the more volume information you provide an individual and the more explicit it is, the slower their drinking time. This is stated with caution as these results need to be independently replicated and the relative contribution of the number of markings and their explicitness needs to be teased apart.

One possible explanation of the effect we observed is that individuals may use volume perceptions to titrate their drinking rate. When an individual begins to consume an alcoholic beverage, they may aim to control their drinking speed partly based on volume perceptions in order to regulate their intoxication. As they continue to consume the beverage, they may titrate the speed and volume that they drink in part, based on volume judgements. Statistical evidence for longer intervals between sips in the marked glass group in Study 5 would support this interpretation. Marking the midpoint in Study 4 may have not have supplied the adequate amount (i.e. one marking may not be sufficient to inform volume perception) and type (i.e., implicit marking may not adequately inform participants of volume that it denotes) of volume information to better inform volume judgements and subsequent consumption. It may be the case that providing explicit volume information in the top half of the shape of the specific glass we tested is critical to assist the drinker in making accurate volume judgements as this area has the most potential for perceptual error. The 3/4 volume marker in Study 5 may have provided the accurate volume information necessary to establish a slower rate of consumption which may be important as it has been suggested that perceived consumption affects subsequent behaviour i.e. individuals who perceive that they have consumed a little will compensate with an increase in consumption volume and/or rate (Raghubir & Krishna, 1999). The differences in height between the 1/4, 1/2 & 3/4 volume markers indicates that the majority of the volume in a curved glass resides near the top of the glass and participants may have altered their consumption in response to this.

These results have policy implications if the effects seen in Study 5 can be replicated in future research. The intervention will need to be implemented legislatively, due to the demand to implement the intervention voluntarily by the alcohol industry and public houses predicted to be low. In the United Kingdom, the 2003 Licensing Act (Licensing Act, 2003) afforded powers to local licensing authorities to issue alcohol licences and enforce the conditions of the licence in their area. A local licensing authority would be able to add a requirement to stock glasses with volume information to its “menu” of licensing conditions which it can require premises to accept in order to be granted a license or have a license renewed. The police or local licensing authority may deem it worthwhile to require that more glasses with volume information be stocked in existing licensed premises to bring about a reduction in crime and public disorder associated with alcohol misuse (Collins, 1981; HM Government, 2007; Plant et al., 2002). Glassware is replaced on a regular basis (due to breakages and new glass designs delivered by the alcohol industry); therefore the transition to glassware containing volume information would have minimal impact on public houses.

There are limitations to these studies that should be considered when interpreting the results. Firstly, the volume marking in Study 4 did not explicitly inform the drinker that it constituted the volume midpoint of the glass and the results may not reflect the true influence of explicit midpoint volume information. Also, participants may have been unable to detect the difference (1% ABV) in lager strengths. Secondly, we used beverage volumes that are somewhat smaller than those typically served in the United Kingdom. However, while it would be useful to replicate these findings with larger volumes, there are no particular reasons to think that our results would only apply to these smaller volumes. Thirdly, the mean AUDIT score of the participants was suggestive of hazardous drinking. The participants were all weekly consumers of alcohol and comprised many undergraduate students. Scores falling within the hazardous range are common in this population and these scores are comparable with findings from our previous research using this measure in these individuals. Finally, the evidence for an effect in Study 5 was only present when outliers were removed.

Future studies should attempt to replicate these findings in less frequent drinkers to examine the generalisability of the effect. Future studies should also investigate applying volume markings to glassware in group conditions and in naturalistic settings. In response to the public increasingly consuming alcohol at home (British Medical Association, 2008), future studies should investigate if volume information can slow drinking times in the home. There are no reasons why the errors in volume perception hypothesised to be influencing drinking rates of alcoholic beverages in these studies would not also occur in the home. It would also be desirable to explore the effect of additional markings denoting units of alcohol as previous research has shown consumers experience difficulty in pouring and monitoring intake of units accurately (Carruthers & Binns, 1992; Gill & Donaghy, 2004; Lemmens, 1994; Stockwell & Stirling, 1989; Turner, 1990). Additional volume markings could also be effective in slowing drinking times further. This could take the form of dividing the volume of the drink into smaller fractions (e.g. 1/8's) or by dividing the volume of the drink into a standard ml amount (e.g. 50 ml) and providing a volume marker at each amount. Haptic cues denoting accurate volume information (e.g. indentations at 3/4, 1/2 and 1/4 volume points) could also be developed to use in distracting environments when visual load could impair the impact of visual cues alone.

In conclusion, these data indicate that accurate volume information can have a modest influence on the rate of consumption of alcoholic beverages, however this is dependent on the specific design of the information. This is possibly due to volume information informing more accurate perceptual judgements which in turn leads to slower consumption, although further research is required to examine the precise mechanisms underlying this effect. Volume information may inform pre-consumption decisions regarding the desired drinking rate necessary to titrate consumption and potentially update these decisions during consumption. If independently replicated in different populations and settings, these findings have the potential to be implemented as a viable choice architecture intervention in drinking environments which may slow consumption rates and corresponding alcohol-related harms

Chapter 5. The effect of nucleation on the likeability and drinking rate of lager in social alcohol drinkers

5.1 Introduction

The design of glassware used to serve alcoholic beverages is constantly evolving. The alcohol industry utilises glassware as an effective vehicle to communicate brand and product information capitalising on the immediacy of glassware to the point of consumption (Stead et al., 2014). A recent development is the addition of nucleated bases to lager glasses. Research is needed to establish what effect this design feature has on the likeability and drinking rate of lager. The likeability of lager is important to research from a public health perspective because drinks that are liked by the population may result in more rapid drinking speeds which will have negative health outcomes.

Nucleation is a process in supersaturated solutions whereby gases such as carbon dioxide (CO_2) are released. Bubbles of CO_2 molecules grow on nucleation sites which usually come in the form of hollow, cylindrical cellulose fibres (Liger-Belair, 2005; Prins, 1998) and are released from these sites when they reach a critical size and ascend through the solution. Bubbles rapidly grow in size as they ascend as well increasing in speed as they travel upward (Shafer & Zare, 1991). Modern lager glasses concentrate the nucleation process by having either a laser-etched or printed nucleated stamp on the inner base, which allows CO_2 to be more rapidly released.

The effect of nucleation on the drinking experience of Champagne and other sparkling wines has been studied more extensively and can inform our understanding of the experience of consuming a nucleated lager. Nucleation in sparkling wines produce rising bubbles that impact the visual perception of wine before the act of tasting and inhaling has begun (Liger-Belair, 2005). The aromatic perception of sparkling wine is influenced due to bursting bubbles releasing gaseous CO_2 and volatile organic compounds above the wine surface (Liger-Belair, Conreux, Villaume, & Cilindre, 2013; Priser, Etiévant, Nicklaus, & Brun, 1997; Tominaga, Guimbertau, & Dubourdieu, 2003). Dissolved CO_2 and collapsing bubbles in the oral cavity interact with trigeminal receptors which are responsible for face sensations (Dessirier, Simons, Carstens, O'Mahony, & Carstens, 2000; Kleemann et al., 2009; Meusel, Negoias, Scheibe, & Hummel, 2010) and gustatory receptors which are responsible for taste (Chandrashekar et al., 2009; Dunkel & Hofmann, 2010). These reactions may influence a lager drinker in similar ways.

There is a lack of research investigating any effect of nucleation on the sensory experience of consuming beer. Studies have examined aspects of lagers such as the head of a beer (which can be maintained for longer by nucleation) or CO_2 content (which can be increased by nucleation). Beer with a sizable head has been judged to taste better than a beer with less head (Bamforth, 2000). Italian consumers concluded that beer with a medium (compared to larger or smaller) level of foam was the best dispensed, most visually appealing, most attractive to consume and most likely to be purchased (Donadini, Fumi, & Faveri, 2011). Beers of higher CO_2 content have been perceived as more bitter (Kosin, Savel, Evans, & Broz, 2012; Ono, Hashimoto, Kakudo, Nagami, & Kumada, 1983) and CO_2 has been deemed to have an important role in conveying beer flavour, aroma delivery and mouth feel (Carroll, 1979; Clark, Linforth, Bealin-Kelly, & Hort, 2011; Meilgaard, 1982).

In summary, 'head' and CO_2 content, which are altered by nucleation, appear to affect the sensory experience of consuming beer. In this chapter, I investigated the effect of nucleation on the self-reported likeability of lager and amount of lager consumed (Study 6). Hypothesis was as follows:

H_1: Lager in nucleated glasses will be rated as more likeable than lager in non-nucleated glasses.

H_0: No difference in likeability of lager between the two glasses.

I also investigated the effect of nucleation on the drinking rate of lager, and explored the relationship between likeability and drinking rate (Study 7). It was difficult to predict any direction of effect: if the likeability of nucleated lagers is greater than non-nucleated lagers, this may speed up consumption due to a more pleasant and rewarding drinking experience, but equally the increased effervescence may lead consumers to savour the more likeable drinking experience and be less concerned with finishing the drink before it goes "flat". This study was therefore more exploratory in nature.

5.2 Study 6

5.2.1 Methods

Design and overview. This was a human laboratory experimental study investigating the effect of nucleated glasses on the drinking experience of lager. It was a within-subjects double-blind design with one factor of glass type (nucleated, non-nucleated). A within-subjects design was chosen to minimise the effect of individual differences in drinking behaviour on results. The presentation of the glasses was counterbalanced and each condition was populated with an equal number of participants stratified by sex. The primary outcome measure was the likeability of lager. Ethics approval was granted by the Faculty of Science Research Ethics Committee at the University of Bristol (reference: 29011512321) and the study was conducted in accordance with the principles of the Declaration of Helsinki (2013) and Good Clinical Practice guidelines (6th revision). Written informed consent was obtained from all participants. The study protocol was registered at http://osf.io/yzvk5 prior to data collection.

Participants. Social alcohol drinkers who reported consuming between 10 and 50 units/week if male or between 5 and 35 units/week if female, were recruited from the staff and students of the University of Bristol, and from the general population by means of poster and flyer advertisements, existing database of participants and word-of-mouth. Participants were required to be in good psychological and physical health, aged between 18 and 40 years, and not currently taking any psychiatric medication. Exclusion criteria included current use of illicit substances (excluding cannabis), a strong family history of alcoholism (defined as at least one first-degree relative or two or more second degree relatives), weighing less than 50 kg if female or 60 kg if male and not drinking/liking lager. Eligibility was ascertained by self-report. Participants were asked to abstain from alcohol consumption for 24 hours prior to the test session, and were only enrolled onto the study if they provided a zero breath alcohol concentration reading at the start of the session. This criteria was included as consuming alcohol in the 24 hours before the session may have influenced ratings on the likeability questionnaire. Participants were reimbursed £5 or awarded course credit, as appropriate, at the end of the study.

Materials. The alcoholic beverage used was standard strength (Budweiser™ 4.8% ABV) lager. Glassware used were Senator beer glasses (volume: 10 UK fl oz, 280ml; Figure 12) designed by Paşabahçe. One was a 'Super Activator Max' nucleated glass, and the other was non-nucleated. The glasses were identical in all other respects.

Figure 12. Senator beer glass (left) with its nucleated base (right).

Questionnaire measures comprised the AUDIT (Saunders et al., 1993) and a Lager Drinking Experience Questionnaire (LDEQ) amended from a taste test questionnaire used with permission from colleagues at the University of Liverpool (Field et al., 2007; Field & Eastwood, 2005; Jones et al., 2011). The LDEQ contained ten questions, which were rated on a VAS from "Not at All" to "Extremely" from 0-100. Four questions ("How smooth is this drink?", "How light is this drink?", "How sweet is this drink?", "How intoxicating is this drink?") acted as filler to disguise the real purpose of the study and were not analysed. The question "How bubbly/gassy is this drink?" served as a manipulation check. A total likeability score was calculated by averaging the responses to questionnaire items measuring visual appeal ("How visually appealing is this drink?"), enjoyment ("How enjoyable is this drink?"), refreshment ("How refreshing is this drink?"), tastiness ("How tasty is this drink?") and likelihood to buy ("How likely would you be to buy this drink?").

Procedure. Participants attended one study session lasting approximately 30 minutes. Participants were sent the information sheet in advance of the study session, and were given the opportunity to read it again upon arrival and ask questions. After informed consent had been obtained, a screening procedure was conducted to assess eligibility for the study, based on inclusion/exclusion criteria. Recent alcohol consumption was assessed by breath test (AlcoDigital 3000, UK Breathalysers). Weight was also recorded to assess eligibility.

Participants were asked to turn their phone off and place it out of reach. They were presented with 100 ml of water as a thirst quencher and consumed as much as they liked. Baseline testing begun with participants completing the AUDIT. While the AUDIT was being completed, 10 UK fl oz of lager was poured into a glass (either nucleated or non-nucleated glass as per randomisation) by a second experimenter (to maintain double-blinding) in a nearby kitchen and delivered to the test room. Drinks were chilled prior to serving and were poured immediately prior to consumption in order to ensure that carbonation was consistent across participants. The second experimenter presented the drink to the participant and the primary experimenter instructed the participant to consume as much of the drink as they wanted over a duration of 5 minutes, complete the LDEQ whilst doing so and place the glass in an adjacent box (to maintain double-blinding) when finished consuming. All 5 minute periods were started after the primary experimenter said "You may begin" and were recorded by stop-watch. The primary experimenter left the room for 5 minutes and then returned with another 100 ml of water for the participant to cleanse their palette. Participants were then given a magazine, and a 5 minute break commenced. The primary experimenter returned to the room after the 5 minute break was over. The second experimenter prepared another 10 UK fl oz of lager (either nucleated or non-nucleated glass as per randomisation) and delivered it to the test room. The procedure followed for the first drink was repeated and the same instructions were given.

Before leaving the testing room, participants were asked to read and sign a safety form that advised them that they had received alcohol and that they should not drive, cycle, operate machinery or engage in any other task or behaviour considered potentially hazardous after alcohol consumption. Participants were debriefed and reimbursed. Participants were offered the opportunity to stay behind to allow any effects of alcohol to wear off and a taxi home. When the participant left, the primary experimenter measured the remaining volume from the first and second drink (the participant was naïve to this).

Statistical analysis. A previous study (Gates, Copeland, Stevenson, & Dillon, 2007) indicated an effect size of $dz = 0.27$ (given a correlation of $r = 0.74$ between responses in the two conditions) for the difference in the palatability ratings of beer. To detect the same effect size, I required a sample size of 110 in order to achieve 80% power at an alpha level of 5%. This was increased to 112 participants to allow for equal numbers of males and females in each glass condition.

Questionnaire responses were captured via online survey platforms (Bristol Online Survey & Qualtrics) and imported into SPSS. Volume consumption data was extracted from case report forms. Data from five questionnaire items in the LDEQ ("How visually appealing was the drink?"; "How enjoyable was the drink?"; "How refreshing was the drink?"; "How tasty was the drink?"; "How likely would you be to buy the drink?") were averaged to calculate a likeability score. Other questions ("How smooth was the drink?", "How light was the drink?", "How sweet was the drink?", "How intoxicating was the drink?") acted as filler questions and were not analysed. These questions were not included in calculating the likeability factor as they were judged to not be as relevant to ascertaining the likeability of lager than the included questions.

The primary outcome was the likeability of lager in nucleated and non-nucleated glasses analysed using a paired-samples *t*-test. Secondary outcomes were the volume consumed for each glass condition, and the responses to the individual questionnaire items that constituted the likeability factor for each glass condition. These were analysed individually using paired-samples *t*-tests. As a manipulation check, responses to "How bubbly/gassy is this drink?" for each glass condition were analysed using a paired-samples *t*-test. Exploratory Pearson's correlations were carried out to assess the relationship between likeability score and volume consumption and between visual appeal and volume consumption respectively. Outliers were detected based on likeability scores via boxplots and defined as 1.5 times the IQR above quartile 3 or below quartile 1. All analyses were conducted using SPSS Statistics Software (IBM SPSS Statistics for Windows, Version 23.0, IBM Corporation).

5.2.2 Results

Participants (n = 116) were on average 21 years old (SD = 4, range = 18 to 37) with an AUDIT score of 10 (SD = 4, range = 4 to 26). When asked what drink they preferred after consuming both, 54% of participants chose the nucleated lager. Four extra participants were tested to balance the number of participants in each condition after a randomisation error during testing.

Manipulation check. As a manipulation check, responses to "How bubbly/gassy is this drink?" were analysed. A paired-samples *t*-test found strong evidence for a difference in the nucleated (M = 72.4, SD = 20.1) compared to the non-nucleated (M = 58.5, SD = 23.6) condition suggesting that lager in nucleated glasses was more bubbly/gassy compared to lager in non-nucleated glasses (Table 11). Removing outliers marginally strengthened this effect. These results suggest the experimental manipulation worked as intended.

Likeability. A paired-samples *t*-test found no clear evidence for a difference in the likeability of lager from a nucleated glass (M = 63.3, SD = 13.9) and a non-nucleated glass (M = 62.5, SD = 14.0) glass (Table 11). Removing two likeability scores classed as outliers did not meaningfully change the results.

Table 11. Differences in likeability of lager, aspects of the lager drinking experience and volume of lager consumed between nucleated and non-nucleated conditions.

	Full sample (*n* = 116)			Outliers excluded (*n* = 114)		
	MD	95% CI	*p*-value	MD	95% CI	*p*-value
Total (Likeability) Score	0.8	-2.4, 3.9	0.638	0.7	-2.4, 3.8	0.657
Likeability sub-scales:						
Visual Appeal	9.3	5.0, 13.6	<0.001	10.1	6.1, 14.2	<0.001
Enjoyment	2.1	-2.0, 6.3	0.313	2.2	-2.0, 6.4	0.294
Refreshment	3.3	-0.6, 7.2	0.096	3.4	-0.6, 7.4	0.091
Tastiness	0.3	-4.1, 4.8	0.884	0.4	-4.1, 4.9	0.874
Likelihood to Buy	-0.1	-4.9, 4.7	0.960	-0.1	-4.9, 4.8	0.980
Other items:						
Bubbly/Gassy	13.9	8.9, 18.9	<0.001	14.1	9.1, 19.2	<0.001
Volume Consumed	0.4	-9.5, 10.4	0.930	0.7	-9.4,10.7	0.896

MD = Mean Difference. CI = Confidence Interval.

A paired-samples *t*-test found strong evidence for a difference in visual appeal of lager consumed from a nucleated glass (M = 73.6, SD = 18.0) compared to a non-nucleated glass (M = 64.3, SD = 20.0) (Table 11), suggesting the lager in a nucleated glass was more visually appealing. Removing outliers (n = 2) did not change the effect meaningfully (Table 12). There was also weak evidence for a difference in the refreshment of lager consumed from a nucleated glass (M = 71.0, SD = 16.8) compared to a non-nucleated glass (M = 67.6, SD = 18.7) (Table 11), suggesting the lager in a nucleated glass was more refreshing. Removing outliers (n = 2) did not change the effect meaningfully. There was no clear evidence to suggest meaningful differences in responses to the other three questions constituting the likeability factor.

Volume consumption. A paired-samples *t*-test found no clear evidence for a difference in the volume of lager consumed from a nucleated glass (M = 183.5 ml, SD = 75.5 ml) and a non-nucleated glass (M = 183.1 ml, SD = 75.6 ml) (Table 11). Removing outliers did not alter these results meaningfully.

Likeability and volume consumption. In exploratory analyses, Pearson's correlations investigated the correlation between likeability and volume consumed separately for nucleated and non-nucleated glass conditions. For nucleated glasses, there was no clear evidence of a correlation in the full sample (r = .11, p = 0.25, n = 116) or when outliers were removed (r = .04, p = 0.70, n = 114). Similarly, no clear evidence of a correlation was found in the non-nucleated glass condition in the full sample (r = .13, p = 0.15, n = 116) or when outliers were removed (r = .12, p = 0.211, n = 114).

Visual appeal and volume consumption. In further exploratory analyses, Pearson's correlations found evidence of a positive correlation between visual appeal and volume consumed in the nucleated condition in the full sample (r = .30, p = 0.001, n = 116). The correlation weakened slightly when outliers were removed (r = .26, p = 0.006, n = 114). There was no clear evidence of a correlation in the non-nucleated condition in the full sample (r = .14, p = 0.13, n = 116), although there was weak evidence of a positive correlation when outliers were removed (r = .16, p = 0.083, n = 114).

5.2.3 Discussion

Results suggest there was no difference in the overall likeability of lager consumed from nucleated and non-nucleated glasses, and exploratory analyses revealed no clear relationship between likeability and volume consumed. When individual questionnaire items were analysed, there was strong evidence that lager consumed from a nucleated glass was rated as more visually appealing than lager consumed from a non-nucleated glass. Exploratory analyses revealed a positive correlation between ratings of visual appeal and volume of lager consumed in nucleated and non-nucleated glasses suggesting the higher rating of visual appeal, the more volume was consumed. The nucleation of glassware appears to increase the visual appeal of lager and visual appeal appears to be positively correlated with more volume consumption. Nucleation may be aimed at improving the visual appeal of lagers in order to increase the sales of alcoholic beverages or increase brand preference. Nucleated lagers were rated as being more bubbly/gassy than non-nucleated lagers suggesting that the experimental manipulation had the proposed effect. Although there was no clear evidence to suggest a difference in the amount of volume consumed from nucleated and non-nucleated glasses in a set time period of five minutes, further investigation was warranted to determine if nucleation has an influence on drinking rate.

5.3 Study 7

5.3.1 Methods

Design and overview. This was a human laboratory experimental study with a between-subjects design with glass (nucleated, non-nucleated) as the predictor. A between-subjects design was used to avoid carry-over effects between conditions which may have been present in Study 6. The primary outcome measure was time taken (from initiation of first sip to completion of last sip) to consume an alcoholic beverage. Ethics approval was granted by the Faculty of Science Research Ethics Committee at the University of Bristol (reference: 31031633763) and the study was conducted in accordance with the Declaration of Helsinki (2013) and Good Clinical Practice guidelines (6th revision). Written informed consent was obtained from all participants. The protocol was registered at http://osf.io/rcmuj prior to data collection.

Participants. Identical criteria were used to select participants as in Study 6, with an additional exclusion criterion of not having taken part in Study 6 or a previous experiment investigating the effect of glass markings on drinking rate. Participants were reimbursed £7 or awarded course credit, as appropriate, at the end of the study.

Materials. The same alcoholic beverage as in Study 6 was used. Glassware used were tulip shaped beer glasses (volume: 20 UK fl oz, 568ml; Figure 13) supplied by Paşabahçe. One was a 'Head Keeper' nucleated glass, and the other was non-nucleated. Glasses were otherwise identical. The glass was chosen because it is a commonly used glass in terms of volume and shape among the wider public.

Figure 13. Tulip beer glass (left) and its nucleated base (right).

Questionnaire measures were identical to Study 6 with the addition of the AUQ (Bohn et al., 1995) to assess craving for alcohol and the PANAS (Watson et al., 1988) to assess mood. The National Adult Reading Test (NART) and an online word search task were also included as dummy tasks to mask the purpose of the study.

Procedure. Participants attended one study session lasting approximately 45 minutes. Participants were sent the information sheet in advance of the study session, and were given the opportunity to read it again upon arrival and ask questions. Participants were told that the study examined the effects of alcohol consumption on word search performance, in order to disguise the primary outcome measure. After informed consent had been obtained, a screening procedure was conducted to assess eligibility, based on inclusion/exclusion criteria. Recent alcohol consumption was assessed by breath test (AlcoDigital 3000, UK Breathalysers). Participants were eligible if their alcohol breath test result was zero and if they self-reported as not having consumed alcohol within 24 hours of the study session. Weight was also recorded to assess eligibility.

In the main session, participants were asked to turn their ‘phone off and place it out of reach. They were presented with 100 ml of water as a thirst quencher and consumed as much as they liked. Self-report measures of alcohol use (AUDIT), alcohol craving (AUQ) and mood (PANAS) were obtained. Participants completed the NART and then received 20 UK fl oz (i.e., a full pint glass) of lager (5% ABV Budweiser in a nucleated or non-nucleated glass as per randomisation). Drinks were chilled prior to serving and were poured immediately prior to consumption in order to ensure that carbonation was consistent across participants.

Participants were told that they should consume all of the drink at their own pace whilst watching a nature documentary (Earth: The Journey of a Lifetime, BBC Worldwide 2008). The experimenter started the film (at the same point in the film and in the session for all participants) and left the room. The drinking session was recorded using a video camera (Hitachi Hybrid Camcorder DZHS500E) to allow for extraction of drinking times. Participants opened the door when they had finished their beverage, the experimenter returned and presented participants with the LDEQ and an online word-search task in which they were instructed to find as many words as possible in four minutes. This was intended to disguise the nature of the study, and these data were not analysed. Then, measures of alcohol craving (AUQ) and mood (PANAS) were administered again. Finally, participants were debriefed and reimbursed.

Before leaving the testing room, the participant was asked to read and sign a safety form that advised them that they had received alcohol and that they should not drive, cycle, operate machinery or engage in any other task or behaviour considered potentially hazardous after alcohol consumption. Participants were fully informed of the purpose of the study upon completion of their participation, and were reimbursed. Participants were offered the opportunity to stay behind to allow any effects of alcohol to wear off and a taxi home.

Statistical Analysis. A previous study resulted in a longer drinking time for straight glasses (M = 11.5, SD = 5.6) compared to curved glasses (M = 7.2, SD = 3.3). This indicated an effect size of d = 0.91 for the difference in drinking rate between the two glass shapes. However, in order to be conservative, we recruited a sample size of 160 participants, which provided 80% power at an alpha level of 5% to detect an effect size of d = 0.45, which is equivalent to a difference in drinking rate of 2 minutes (SD = 4.5).

Questionnaire responses were captured via online survey platforms (Bristol Online Survey & Qualtrics) and imported into SPSS. Drinking time data was extracted from videos. The primary outcome measure was total drink time (from initiation of first sip to termination of last sip) and I analysed these data were analysed in a linear regression, with glass type (nucleated, non-nucleated) as a between-subjects factor. Linear regressions with glass type as predictor adjusting for baseline mood/craving were used to analyse mood (PANAS) and craving (AUQ) data respectively. Linear regressions were used here instead of independent samples t-tests to communicate the data more clearly to the reader. Responses to the question “How bubbly/gassy was the drink?” served as a manipulation check and was analysed using an independent samples t-test, with glass type as a between-subjects factor. Likeability scores were calculated the same as in Study 6 and individual questionnaire items that constituted it were analysed using independent samples t-tests, with glass type as a between-subjects factor. To examine the association between total drinking time and likeability score, a Pearson's correlation was conducted. An exploratory Pearson's correlation was carried out to assess the relationship between visual appeal and total drinking time in light of the finding in Study 6 that nucleated lagers were more visually appealing than non-nucleated lagers. Outliers were detected based on drinking times via boxplots and defined the same as in Study 6. All analyses were conducted using SPSS Statistics Software (IBM SPSS Statistics for Windows, Version 23.0, IBM Corporation).

5.3.2 Results

Participants (n = 160; 50% female) were on average 21 years (SD = 4, range 18 to 40) and had an average AUDIT score of 9 (SD = 4, range = 2 to 22). Participant characteristics are detailed in Table 12. Two participants were excluded from analysis due to video malfunctions making their data unusable. Missing questionnaire responses were imputed based on the median of the sample for that specific question. Five outliers were removed based on their drinking time using the same exclusion criterion as Study 4.

Table 12. Characteristics of participants.

	Nucleated (n = 80)	Non-nucleated (n = 80)
Sex (female)	40 (50%)	40 (50%)
Age (years)	21 (4)	21 (4)
AUDIT	9 (4)	9 (3)

Standard deviation is shown in parentheses for continuous measures. AUDIT = Alcohol Use Disorders Identification Test.

Total drinking time. There was no clear evidence that nucleation was associated with total drinking time in the full sample or when outliers (n = 5) were removed (Table 13).

Table 13. Effect of glass markings on total drinking time (min:sec/0.6).

	Mean drinking time				
	Nucleated	Non-nucleated	Mean difference	95% CI	*p*-value
Full sample (n = 160)	18.16	16.70	1.46	-1.04, 3.95	0.251
Outliers excluded (n = 155)	16.91	16.31	0.61	-1.48, 2.70	0.566

CI = Confidence Interval.

Alcohol craving and mood. There was no clear evidence for a difference in post-consumption alcohol craving for AUQ data or PANAS measures of positive or negative affect between nucleated and non-nucleated conditions (Table 14).

Table 14. Effect of glass markings on post-drinking alcohol craving and mood.

		Adjusted for baseline		
		Mean difference	95% CI	*p*-value
Full sample (n = 160)	AUQ	-0.70	-0.37, 0.23	.652
	Positive affect	-1.03	-2.53, 0.46	.173
	Negative affect	-0.39	-1.01, 0.23	.217
Outliers excluded (n = 155)	AUQ	-0.35	-0.35, 0.28	.826
	Positive affect	-1.08	-2.59, 0.44	.163
	Negative affect	-0.34	-0.97, 0.30	.302

AUQ = Alcohol Urges Questionnaire.

Manipulation check. There was no clear evidence in the full sample (Table 15) or when outliers (*n* = 5) were removed (Table 15) for a difference in responding to the question 'How bubbly/gassy was the drink'? suggesting that the experimental manipulation did not have the desired effect of changing the perception of how bubbly/gassy the drink was between the two conditions.

Likeability factor. An independent samples *t*-test found no clear evidence for a difference between the likeability of lager from a nucleated (*M* = 62.8, *SD* = 19.3) glass and a non-nucleated (*M* = 63.5, *SD* = 18.5) glass (Table 15). Removing five outliers did not meaningfully change the results. There was no clear evidence to suggest differences in responses to the five questions constituting the likeability factor.

Table 15. Differences in likeability of lager and aspects of the lager drinking experience between nucleated and non-nucleated conditions.

	Full sample (n = 160)			Outliers excluded (n = 155)		
	MD	95% CI	p-value	MD	95% CI	p-value
Total (Likeability) Score	0.7	-5.2, 6.6	.816	0.2	-5.8, 6.1	.958
Likeability sub-scales:						
Visual Appeal	1.6	-5.3, 8.5	.643	0.3	-6.6, 7.3	.928
Enjoyment	2.3	-4.6, 9.1	.515	1.5	-5.3, 8.3	.665
Refreshment	3.2	-2.9, 9.2	.301	3.5	-2.7, 9.6	.268
Tastiness	-1.3	-7.9, 5.4	.709	-1.4	-8.1, 5.3	.687
Likelihood to Buy	-2.3	-9.8, 5.2	.541	-3.1	-10.5, 4.3	.409
Other items:						
Bubbly/Gassy	0.8	-5.0, 6.7	.837	0.3	-5.6, 6.3	.911

MD = Mean Difference. CI = Confidence Interval.

Likeability and total drinking time. In the nucleated condition, Pearson's correlations revealed evidence that likeability and drinking time were negatively correlated (i.e. the more likeable their lager, the faster their drinking time) in the full sample (r = -.30, p = 0.007, n = 80) and when outliers were removed (r = -.22, p = 0.058, n = 76). In the non-nucleated condition, there was evidence to suggest likeability and total drinking time were negatively correlated in the full sample (r = -.27, p = 0.015, n = 80) and when an outlier was removed (r = -.22, p = 0.048, n = 79).

Visual appeal and total drinking time. Given the difference in visual appeal between nucleated and non-nucleated conditions in Study 6, it would seem important to investigate the relationship between visual appeal and drinking rate in this study. In exploratory analyses, Pearson's correlations found evidence to suggest a negative correlation in nucleated lagers between visual appeal and total drinking time in the full sample (r = -.30, p = 0.006, n = 80) but the effect weakened when outliers were removed (r = -.18, p = 0.12, n = 76). No clear evidence was found in non-nucleated lagers for a relationship between visual appeal and total drinking time in the full sample (r = -.17, p = 0.13, n = 80). However, weak evidence was found when an outlier was removed (r = -.21, p = 0.069, n = 79).

Reliability analysis. Ratings of total drinking time carried out by two raters were strongly and positively correlated, single measures intraclass correlation (rs > .96, ps < 0.001), indicating a high level of inter-rater reliability.

5.3.3 Discussion

Results suggest no clear evidence for an effect of nucleation on likeability and drinking rate or an effect of nucleation on changes in post-consumption mood or alcohol craving. Results showed strong, negative correlations between likeability and total drinking time in both the nucleated and non-nucleated conditions suggesting that the more people liked their drink, the faster their drinking time. Exploratory analyses revealed a negative relationship between visual appeal and total drinking time with varying degrees of evidence in nucleated and non-nucleated conditions, suggesting that the more visually appealing people perceived their drink to be, the faster their drinking time. Nucleation appeared to have no differential effect on the strength of these correlations. Nucleation may not sufficiently affected the sensory experience of consuming lager in order to alter drinking rate. However, as the experimental manipulation did not have the desired effect, the true effect of nucleation may not have been seen in this study and interpretations of results should be treated with caution.

5.4 General Discussion

Contrary to my hypotheses, the nucleation of glassware did not alter the likeability of lager in either study. In Study 6, there was strong evidence that the visual appeal of lager was greater and weak evidence that refreshment was greater in nucleated compared to non-nucleated glasses. These findings were not replicated in Study 7. Nucleation did not appear to affect lager consumption in terms of volume consumed in a set time period (Study 6) or drinking rate (Study 7). Correlations in both studies displayed a similar pattern in so far as the more visually appealing a drink was perceived to be, the more volume was consumed and the faster it was consumed. Likeability ratings were negatively correlated with drinking time is Study 7, however there was no clear evidence for a relationship in Study 6. It appears that nucleation had no clear differentiating effect on any of these correlations.

One possible explanation for the lack of difference in likeability is that nucleation did not alter responses to enough individual items that constituted the likeability score to a large enough degree. There was no clear evidence for a difference in likelihood to buy, enjoyment, tastiness between nucleated and non-nucleated lagers in Study 6 suggesting that increased visual appeal and refreshment did not translate to a change in these aspects of the drinking experience. In support of Study 6's findings on visual appeal, participants in other studies have been observed paying attention to the continuous flow of ascending bubbles during champagne and sparkling wine tasting and noting their visual appeal (Liger-Belair, Polidori, & Jeandet, 2008). Similarly, a medium level of beer 'head' foam has been judged the most visually appealing by both males and females (Donadini et al., 2011). The effervescent effect of ascending bubbles and beer 'head' which can be maintained for longer by nucleation appear to be visually attractive to drinkers.

There was no clear evidence for a difference found in any of the five individual questionnaire items that constituted the likeability factor in Study 7. A possible explanation could be the difference in study design. Presenting two drinks in quick succession in Study 6 may have made the differences between them more perceptible. Another possible factor could be the difference in perceived effect of nucleation in both studies. Participants judged lager in nucleated glasses as being more bubbly/gassy than lager in non-nucleated glasses in Study 6 but not in Study 7. This could be due to the different time spent consuming beverages in both studies (i.e., five minutes in Study 6, approx. 17 mins in Study 7). The effect of nucleation does diminish over time; therefore participants in Study 7 would have observed the lager being less bubbly/gassy in the nucleated condition for a longer period of time than participants in Study 6.

The perceived increase in visual appeal and refreshment in nucleated glasses in Study 6 did not lead to a difference in volume consumed. It is possible that a difference in these measures would not alter consumption in a five-minute period but may affect consumption over a longer period of time, although this was not borne out in Study 7. It has been suggested that the intention of nucleating glassware is to replenish and maintain the head of foam during the consumption of beer (Quain, 2007). It is plausible that the nucleating of glassware is primarily focused at improving the drinking experience of lager, which we saw some evidence for in Study 6, while not explicitly attempting to change the rate of consumption. This is a potential explanation for the lack of a meaningful difference in volume consumed in Study 6 or drinking rate in Study 7. It should be noted that the experimental manipulation did not have the intended effect in Study 7; therefore any true effect of nucleation may not have been seen. Further investigations into the effect of nucleation on drinking rate are needed to corroborate and provide stronger evidence that nucleation has no meaningful effect on drinking rate.

In Study 6, there was strong evidence to suggest a positive relationship between visual appeal and volume consumed (i.e., the more people rated their drink as visually appealing, the more of it was consumed) in nucleated lagers and non-nucleated lagers. In Study 7, there was evidence for a negative relationship between visual appeal and total drinking time in nucleated and non-nucleated lagers (i.e., the more people rated their drink as visually appealing, the faster it was consumed). In Study 6, results revealed no clear evidence for a relationship between likeability and volume consumed in nucleated and non-nucleated conditions. However, in Study 7, there was evidence of varying strength to suggest a negative association between likeability and total drinking time in nucleated and non-nucleated conditions. These findings are in line with other research that found that pleasantness ratings of alcoholic drinks are a predictor of *ad-libitum* alcohol consumption (Jones et al., 2016).

The nucleating of glassware may fit within the wider context of glassware being more readily used as a marketing tool within the industry to communicate product information to the consumer (McFarland, 2002). Increasing the visual appeal and refreshment of lager through innovations in glassware may be aimed at increasing market share. Changing the visual appearance of Stella Artois glassware has been claimed to increase sales by 9.7% year on year (McFarland, 2002) and the introduction of a 'Stella Artois 4%' glass increased sales by 14% compared to older glasses (Lewis, 2009; Turney, 2009). Although, the lack of difference in the responses to the likelihood to buy question in both studies would suggest that nucleation may not influence purchase decisions.

Some limitations should be considered when interpreting these findings. First, in Study 7, the experimental manipulation appeared to not to have the planned effect of altering the perception of how bubbly/gassy lagers were in the two conditions; therefore, results may not represent the true influence of nucleation on drinking rate. Future studies investigating the effect of nucleation on drinking rate should use optimal nucleation stamps to ensure a discernible difference between nucleated and non-nucleated lagers. Second, both studies were carried out in a laboratory setting and findings may not generalise to naturalistic environments. Third, the likeability questionnaire used in Study 6 was not a validated measure of likeability of lager and its construct validity is unknown. Therefore, it may not an accurate measure of the likeability of lager. Fourth, the volume of glassware in Study 6 does not correspond to volumes traditionally consumed among the wider public and findings may not generalise to larger volumes. However, there is no reason why the greater visual appeal in nucleated lagers would not translate to larger volumes especially if rising bubbles is the source of the visual appeal as has been found in other studies (Liger-Belair et al., 2008). Fifth, the average AUDIT score of participants in both studies was suggestive of harmful drinking and findings may not generalise to people with different drinking patterns. Finally, Study 7 was under-powered to detect the small effects that were observed. These small changes in drinking speed may be important and future studies should test a larger sample size to ascertain if nucleation has any relevance at the population level.

In conclusion, there was no meaningful difference in overall likeability of lager consumed from nucleated and non-nucleated glasses. In Study 6, lager in nucleated glasses was rated as more visually appealing and refreshing than lager in non-nucleated glasses, however this was not replicated in Study 7. Further research should investigate the replicability of these effects. Nucleation appears to have no effect on the consumption in lager in terms of amount of volume consumed or drinking rate. Based on findings in these studies, nucleation does not appear to have potential as a target for public health interventions. However, future research should investigate the effect of nucleation on the consumption of alcoholic beverages and determine if the null findings seen here are found consistently across studies.

Chapter 6. General Discussion

6.1 Overview

This thesis investigated the potential of using glassware based CAIs to change alcohol-related behaviours and the feasibility of changing glassware in naturalistic settings. The findings of seven studies were presented. A focus of the thesis was to assess the challenges of carrying out research on the effect of glassware on alcohol consumption in the real-world. Therefore, the feasibility of running a study manipulating glassware in a pub setting was investigated in Study 1. A major focus was investigating the effect of glass shape on the pouring of liquid and the consumption of alcoholic beverages. Studies 2 and 3 investigated the effect of glass shape on the pouring accuracy of liquid volume. Studies 4 and 5 assessed the effect of glass markings on drinking rate in curved glassware. Another focus in this thesis was a design feature of modern lager glasses known as nucleation. Study 6 investigated the effect of nucleation on the likeability of lager and the amount of lager consumed in a set time period. Study 7 looked at the effect of nucleation on the time taken to consume an alcoholic beverage.

6.2 Feasibility of studies in naturalistic settings

In Study 1, the feasibility of manipulating the shape of glassware in a naturalistic environment was investigated. Findings are informative of the potential for straight glasses to reduce alcohol consumption in the real-world. There was a 24% reduction (95% CI 77% reduction to 29% increase) in monetary takings on straight glass weekends compared to curved glass weekends. This result was in the same direction as previous laboratory findings looking at the effect of glass shape on drinking rate . More importantly, the feasibility of using monetary takings as a proxy for consumption was assessed. To investigate this, secondary data was analysed from a pub over a 2-week period. Strong correlations (*rs* > .98) were found for beer, cider and spirit beverage groups. Monetary takings appear to be an accurate proxy for alcohol consumption however there are limitations to this method. Accuracy relies on drinkers consuming all of their purchased beverages. This may not be the case as inevitably drinks may be left unfinished or spilled by customers (i.e. total amount of alcohol sold will not equal total amount consumed). However, if this is a systematic factor affecting both control and intervention glassware equally, it would have limited impact on findings. Monetary takings do not capture individual consumption data across a night's drinking in multiple premises. Straight glassware may lead to individual's leaving the premises and drinking elsewhere, thereby reducing takings in pubs where the study is taking place but not reducing their overall consumption. This could lead to erroneous interpretation of effectiveness of an intervention. An advantage of this method is the customer is naïve to data collection so demand characteristics on their drinking behaviour are avoided. Also, there is no cost to experimenters to collect this data. It does not require extra work on behalf of pub staff and doesn't disrupt normal business. Therefore, it is likely to be acceptable to pub landlords, which was the case in Study 1. The owner of the pubs in Study 1 did not want raw monetary takings data made public. This restricts how researchers can present this data in papers. Takings may have to be aggregated across multiple sites or percentage change used as a primary outcome measure as was the case in Study 1. Ultimately, using monetary takings can be used as a proxy for consumption in naturalistic studies. It can provide a crude estimate of how much alcohol is purchased in premises under experimental investigation but it cannot provide individual level data.

If future research supports altering glassware in the on-licence trade, this is possible through altering the licensing policies of local councils, which are typically renewed every five years. Every local council has a menu of licensing conditions that license holders must adhere to. A council can stipulate what glassware needs to be stocked in premises. The implementation of policies that improve public health need to be imposed on the alcohol industry and licensed premises. The current Public Health Responsibility Deal is a government-led voluntary initiative with large multinational food and drinks companies to reformulate their products and market them responsibly. Initiatives included in the Responsibility Deal are largely ineffective at reducing alcohol use (Knai, Petticrew, Durand, Eastmure, & Mays, 2015). It is fundamentally flawed in its expectation that industry will prioritise public health interests over its own. If glassware based CAIs were shown to be effective, it is unlikely that the alcohol industry would voluntarily agree to support such measures. This is in light of industry actors opposing measures such as MUP that threaten their commercial interests (Holden, Hawkins, & McCambridge, 2012).

The acceptability of glassware based interventions needs to be considered. Some customers did express dissatisfaction with the straight glassware in Study 1. Researchers have found that people generally enjoy drinking beverages more when the receptacle is regarded as being consistent with the contents in non-alcoholic (Cavazzana, Larsson, Hoffmann, Hummel, & Haehner, 2017; Schifferstein, 2009) and alcoholic beverages (Wan, Zhou, Woods, & Spence, 2015). Curved or slanted glassware have been paired with alcoholic beverages repeatedly in on-licensed premises and in marketing and advertising campaigns. They may be seen as product-congruent receptacles and therefore preferred by drinkers (Raudenbush, Meyer, Eppich, Corley, & Petterson, 2002). This may be an obstacle to customers choosing to consume their drink from straight glassware. Interventions such as applying volume markers to curved glassware may be more acceptable to customers. Current evidence suggests that volume markings (Troy et al., 2017) do not slow alcohol consumption as effectively as straight sided glassware (Attwood et al., 2012). However, if consumers choose to consume their drinks from curved glassware with markings over straight glassware, the potential for harm reduction of volume markings may be greater than straight glasses.

6.3 Shape

Studies 2 and 3 investigated the effect of glass shape on the pouring of liquid volume. Findings from Study 2 suggest that individuals pour liquid more accurately in straight glasses at 11 points between 10 and 90% full compared to curved glasses. The results in the straight glass followed a linear pattern. This seems to support the commonly stated theory in the literature (Holmberg, 1975; Piaget, 1967; Piaget, 1968; Raghubir & Krishna, 1999) that individuals use the height of a liquid in a container to judge volume. Pouring was more accurate at points closer to the bottom or top of the glass in both straight and curved glasses. Participants may be combining the use of height as a heuristic for volume in combination with using the bottom or top of the glass as reference points to inform their pouring. The results in the curved glass indicated a quadratic pattern. Pouring was progressively more inaccurate in curved glasses from 10% to 75% full. This may be explained by the fact that changes in liquid closer to the top of the curved glass involves a larger change in volume than the same change in height nearer the bottom of the glass. Pouring improved at 80% and 90% where participants may have used the top of the glass as a reference point to inform their judgements.

Study 3 investigated the effect of glass shape on the pouring accuracy of liquid volume in a café environment. Again, individuals using the height of liquid as a proxy for volume judgements can broadly explain the pattern of results. Pourings were similarly accurate in straight and inverted glasses. This was expected in the straight glass; however, the results in the inverted glass were surprising. A possible explanation is that participants still used height as a heuristic for judging volume but the shape of the glass resulted in participants pouring more liquid compared to tulip and curved glasses. The shape of the inverted glass distributes the majority of volume near the base of the glass reversing what occurs in other shaped glasses that were tested (i.e., curved and tulip glasses distribute more volume towards the top of the glass). The heuristic of using height of liquid as a proxy for volume that results in participants underestimating volume when pouring into tulip and curved glasses seems to lead to more accurate pouring in inverted glasses. Having the majority of volume in the bottom of the glass may move the midpoint volume estimate higher in the glass while having more volume in the top of the glass moves the estimate lower in the glass. Participants tracking the height of liquid would stop pouring at approximately half the height of the glass would pour more volume into the inverted glass than the tulip and curved glass. However, the inverted glass did have a stem while the other glasses did not. This adds complexity when interpreting finding as you have a section on the inverted glass, which adds height but contains no liquid. Perhaps the stem influenced participants to pour liquid to a higher height in the inverted glass rather than the shape. Participants were likely to be less familiar with the inverted glass compared the more commonly used curved and tulip glasses. This may be another factor in the different pouring behaviours seen between glasses. The inverted glass did not result in perfectly accurate pouring but errors were reduced compared to curved and tulip glasses and equivalent to straight glasses.

Research that has investigated the effect of glass shape on the pouring of alcoholic beverages has been mixed. Participants have poured more volume into short, wide glasses compared to a tall, slender glasses when asked to pour a ‘shot’ in laboratory settings (Wansink & Ittersum, 2005). Results appear to be consistent with participants tracking the height of liquid within glasses to inform their poured amount. However, this effect was not replicated in a subsequent study in a bar environment. Shape was found to have no effect on drink pouring behaviour (Kerr et al., 2009). Pouring behaviour in a bar environment may differ compared to laboratory settings. This calls into question the external validity of laboratory studies of pouring behaviour. Findings from Studies 2 and 3 need to replicated in laboratory settings and eventually in naturalistic settings to add support to the claim that glass shape can affect the pouring of alcoholic beverages.

Studies 4 and 5 investigated the effect of glass markings on the drinking rate of lager in curved glassware. It was hypothesised that applying volume markers to curved glassware would mitigate errors in volume judgement that may lead to faster consumption of lager from curved glasses (Attwood et al., 2012). Study 4’s results showed no meaningful slowing of drinking rate when a midpoint volume marker was applied. The yellow tape denoting true midpoint may not have influenced participant’s volume judgements enough to alter their consumption as they may have not been aware that it denoted a midpoint marker as it lacked any text or numeric explanation. The bottom and top of the glass may have been used to inform volume judgements as suggested in Study 2. However, the further away liquid was from the top and bottom of the glass; the more individuals may have relied on their natural heuristic to use height of liquid within the glass to judge volume. It is thought that people commonly use the height of liquid when making volume judgements (Holmberg, 1975; Piaget, 1968). The addition of markers at 1/4 and 3/4 full in Study 5 gave drinkers additional guidance to inform their volume judgements. Including the top and bottom of the glass, participants were provided with five points denoting accurate volume.

Average drinking times from unmarked glasses and marked glasses in Studies 4 and 5 can illustrate the slowing effect of more glass markings. The glass with two additional markers (10.34 mins) was associated with slower consumption compared to the glass with a midpoint marker (9.98 mins). There are some caveats to add. Faster consumption from the unmarked curved glass in Study 5 (9.11 mins) compared to the same glass in Study 4 (9.55 mins) may have inflated the effect seen in Study 5. The drinking times from marked glasses in either study did not reach the average of 11.45 mins seen in straight glasses in a previous study (Attwood et al., 2012). This suggests that changing the shape of glassware from curved to straight appears to be associated with a greater slowing of consumption compared to applying visual aids denoting volume. If there is a positive association between the degree of error in volume judgments and total drinking time as suggested previously (Attwood et al., 2012), visual aids to accurate volume information may not have influenced volume judgements as much as straight glasses. This may be due to the height of liquid in straight glasses changing proportionally with volume during consumption, possibly requiring less conscious effort by drinkers to monitor the amount of liquid they are consuming. Even though the markings in Study 5 supplied drinkers with more information to aid their volume judgements during consumption, this would not give the visual guidance that straight glasses supplies the drinker at all points in the glass. Another factor that may be influencing people to drink differently from curved and straight glasses is the perception of the contents modulated by the shape of glassware. Preliminary work has suggested that beer in curved glasses is perceived as more fruity and intense than in straight glasses (Mirabito, Oliphant, Van Doorn, Watson, & Spence, 2017).

In sum, there appears to be a pattern emerging in the limited number of studies investigating the effect of glassware on drinking rate of alcoholic beverages. The more direction glassware gives an individual with regard to accurate volume, the slower alcohol consumption is. Following this logic, straight glasses would appear to have the most potential to be developed as an effective CAI to slow alcohol consumption. Of course, this is dependent on consumers accepting their alcoholic beverage in straight glassware. If future work replicates the findings in Study 5, applying volume markers at 1/4 intervals to glassware of various shapes could be one of a suite of CAIs that slow alcohol consumption.

6.4 Nucleation

In Studies 6 and 7, the effect of nucleation on the likeability and consumption of lager was investigated. In Study 6, there was no evidence for a meaningful difference in the likeability of lager from nucleated and non-nucleated glasses. However, there was strong evidence that nucleated lagers were more visually appealing than non-nucleated lagers. There was also weak evidence to suggest that nucleated lagers were more refreshing than non-nucleated lagers. Although, comparing findings is problematic as nucleation is not explicitly a factor in studies in the literature; correlates of nucleation have been examined. For example, a correlate of nucleation is the amount of foam in the head of a lager and a medium level of foam was found to be the most visually appealing (Donadini et al., 2011). Similarly, during champagne and sparkling wine tasting, participants were observed paying attention to the continuous flow of ascending bubbles and noting their visual appeal (Liger-Belair et al., 2008). It appears one of the primary effects of nucleation is the enhancement of the visual appeal of alcoholic beverages. Additionally, participants rated nucleated lagers as more refreshing than non-nucleated lagers. The alcohol industry may be attempting to improve the drinking experience of lager to influence consumers to be brand loyal in their purchasing.

How nucleation affects consumption was also assessed in both studies. In Study 6, there was strong evidence of a positive relationship between ratings of visual appeal and volume consumed of lagers in nucleated glasses (i.e., the more people rated their drink as visually appealing, the more of it was consumed). In Study 7, there was evidence for a negative relationship between ratings of visual appeal and total drinking time in nucleated and non-nucleated lagers (i.e., the more people rated their drink as visually appealing, the faster it was consumed). Visual appeal of an alcoholic beverage may influence consumptive behaviour; however, we cannot determine causality from these studies. Direct measures of consumption were assessed in both studies. Study 6 investigated how much lager was consumed from a nucleated glass in a 5-minute period. Results showed no meaningful difference in volume consumed between nucleated and non-nucleated glasses. A possible explanation is that 5 minutes was not long enough time for differences in consumption to become apparent. This limitation was somewhat addressed in Study 7, albeit using a different measure of consumption – drinking rate was assessed as opposed to consumption amount. There was no meaningful difference in the time taken to consume a pint of lager from nucleated and non-nucleated glasses. Together, both studies give a fuller picture of how nucleation affects the consumption of alcoholic beverages. Results suggest that there was no meaningful difference in the amount of lager consumed from a 280 ml glass in 5 minutes or time taken to consume a pint of lager in nucleated and non-nucleated glasses. However, ratings of visual appeal were correlated with more consumption volume in Study 6 and faster consumption in Study 7.

6.5 Future research

Future naturalistic research should combine other data collection methods with monetary takings. Innovative data capture methods can provide avenues to collect individual consumption data in naturalistic environments. Wearable devices have been used in alcohol research that continuously measure alcohol intake via excreted alcohol through the skin via sweat glands (Swift, 2003). Evidence suggests they are a valid and reliable measure of actual consumption (Leffingwell et al., 2013). These devices also have GPS functionality allowing researchers to track the location of the wearer of the devices. Together, these methods would give a picture of consumption on a population and individual level. This combination of consumption data from different methodologies would aid in the interpretation of the effectiveness of glassware based CAIs. Licensing officers have expressed concern that there isn't the evidence available that they need to justify rejecting license applications and establishing cumulative impact zones. They also fear litigation if they implement policies without a sound evidence base (Herring, Thom, Foster, Franey, & Salazar, 2008). To convince licensing officers and committees of the merit of changing the shape and design of glassware, robust evidence that it can reduce consumption across a large number of establishments is needed.

Future research needs to clarify if the behaviour change seen in the studies in this thesis can translate to slowing/reducing real-world alcohol consumption. For example, it is unclear if more accurate pouring of liquid seen in Studies 2 and 3 in straight and inverted glasses can lead to slower consumption speed of self-poured alcoholic drinks. Theoretically, it may be similar to the relationship of the accuracy of volume judgements and drinking rate of lager seen previously (Attwood et al., 2012); the more accurate people perceived the midpoint of a straight or curved glass to be, the slower their consumption of lager. More liquid was poured into the straight glass in Studies 2 and 3 and inverted glass in Study 3. If this is found to replicate when pouring alcoholic beverages, it would be interesting to investigate the relationship between the amount poured and time taken to consume an alcoholic beverage in differently shaped glassware. This could be investigated in a between-subjects design by giving drinkers a certain amount of an alcoholic beverage (i.e., a 568ml can) and asking them to pour it up to the midpoint in different shaped pint glasses. The amount poured would be recorded as well as the time taken to consume the poured amount. This further research would help clarify if slower consumption of more poured volume would result in slower overall consumption time in straight glasses compared to faster consumption of less poured volume in curved and tulip glasses. The risks and benefits of using different shaped glassware when pouring alcoholic beverages need to be teased apart. This research would be relevant for when alcoholic beverages are poured to less than full capacity in a glass. The frequency that this occurs when pouring lager/ale/cider is unclear. It rarely, if ever, happens in the pub trade, however it may happen more frequently during drinking in the home.

It is also unclear if the modest slowing of consumption seen in marked glassware in Study 5 would translate to similar slowing in subsequent drinks in a drinking session. This could be assessed in the laboratory by tweaking the study design used in Study 5 with the addition of a 2nd and 3rd drink in a group of participants. It also needs to be seen if the slowing effect of volume markers can be maintained in a group of drinkers in laboratory settings and ultimately in naturalistic settings. Research on peer influence on drinking rate is limited and based on small sample sizes. Confederates have the ability to increase and decrease participant's (n = 3) rate of consumption of beer in a simulated bar (Dericco & Garlington, 1977). When two confederates drink at different rates in a bar, a participant (n = 1) modelled the faster rate of drinking (DeRicco & Niemann, 1980). When a larger group (n = 12) is drinking, the rate exhibited by the majority of confederates was modelled by participants (n = 3) in a simulated bar (DeRicco, 1978). If these effects are replicated in larger samples of drinkers, it is plausible that if volume markers were applied to all glasses in a group, drinking rates of all drinkers could be slowed. However, if only some drinkers are consuming from glasses with volume markings, any potential slowing effect may be negated by the modelling of faster drinking rates of peers from unmarked glasses. To advance the research begun in Studies 6 and 7, consumption of lager in nucleated glasses must also be assessed over multiple drinks. Visual appeal was correlated with more consumption volume and faster consumption. While no group differences were seen in these outcome measures, this may change over the course of more drinks.

It is also unclear whether the slowing of consumption of an alcoholic beverage seen in Study 5 will translate to reduced overall intake over a drinking session. Many factors may lead a drinker to consume the same amount of alcohol in a session regardless of the speed of consumption. Peer pressure in terms of overt offers of alcohol (e.g., intense goading, commands to drink), modelling concurrent drinking behaviour of peers and perceived social norms of excessive alcohol use are associated with the quantity of alcohol consumption consumed by college students (Borsari & Carey, 2001). Another factor that influences quantity of alcohol consumption is alcohol outcome expectancies – beliefs held by drinkers about the perceived outcomes of drinking. Positive outcome expectancies are beliefs that drinking alcohol will lead to positive outcomes that will be beneficial to the drinker and are generally positively associated with quantity of alcohol consumption in adolescents and adults (Cable & Sacker, 2008; Patrick, Wray-Lake, Finlay, & Maggs, 2010). Perceived parental control predicts heavy alcohol use in adolescents (i.e., strict control is related to lower alcohol use) (Van der Vorst, Engels, Meeus, & Deković, 2006). Price (Wagenaar et al., 2009) and availability (Anderson & Baumberg, 2006; Babor et al., 2003) of alcohol also influence the quantity of alcohol consumed. These are just some of the factors that influence the quantity of alcohol consumption and may prevent volume markers reducing alcohol intake over a drinking session. If this is the case, CAIs that slow alcohol consumption may be still worth pursuing if it can be shown that slower consumption results in reduced alcohol-related harms (e.g., lower levels of intoxication resulting in less injuries).

Future research is needed to develop further interventions similar to the ones tested in Studies 4 and 5. Study 2 showed that volume judgements were more inaccurate between 1/4 and 3/4 full compared to 1/4 to empty and 3/4 to full. Markers at 3/4, 5/8, 1/2, 3/8, and 1/4 might lead to more accurate tracking of volume changes during consumption in this area where drinkers need most direction. This may lead to further slowing of consumption than was seen in Study 5 when the glass was divided into quarters. However, markers in the middle section of the glass may not engaged with as branding information generally is also concentrated in that area of the glass. Future research will need to test if the effect of glass markings on consumption is compromised by branding information on glassware.

A general limitation of my studies was the lack of non-university students taking part. Although, this is an important group to test given their harmful patterns of drinking, drinkers of different ages need to be recruited to take part in alcohol research. This would improve the generalisability of findings to the wider public. Non-university students were recruited in Studies 1 and 2 but I could have done more to recruit drinkers from different age groups to my laboratory studies. Older groups are increasingly engaging in harmful drinking (Health and Social Care Information Centre, 2016) and interventions need to be developed that can also reduce their levels of consumption. Theoretically, the impact of CAIs on the target individual operate on automatic processes outside the conscious awareness (Marteau et al., 2012) so this limitation may be less relevant for my research. However, the acceptability of certain interventions may differ in different age groups and this should be taken into consideration when designing and implementing CAIs.

An oversight when designing Study 1 was not engaging with the pub landlords before glasses were chosen. A pre-study interview may have flagged the need for nucleation stamps on the glassware used in the study. Patrons of the establishments involved in the study did complain that drinks served from experimenter glassware were 'flat'. Also, the concerns of one landlord regarding the replacement and storage of his glass range off-site which led to the withdrawal of his participation after Weekend One could have been dealt with before the start of the study. Studies 2 and 3 could have been of more real-world value if the studies investigated volume judgements from full to empty. This could have been done with minor changes to study designs. Participants in Study 2 could have been presented with a full glass on screen and asked to reduce liquid to requested percentages. Participants in Study 3 could have been presented with full glasses of lager and asked to consume half of the volume of the glass. Investigating and understanding the effect of glass shape on pouring has limited real-world impact compared to understanding the effect of glass shape on volume judgements during consumption. A limitation of Studies 4 and 5 was the difference in design of the volume markers used. A continuous yellow band of tape was used with no numerical information in Study 4 compared to black markers at intervals with numerical information in Study 5. Consistency in the colour and design of the markings would have reduced the potential for differences arising in visual attention and engagement with the markers between studies. Manipulation checks should also have been incorporated into the design of both studies to gauge the degree to which participants attended to the markings. A limitation of Study 7 was using nucleated glassware that was perceived by participants as not resulting in more bubbly/gassy lager compared to non-nucleated glassware. More extensive pilot testing of different types of nucleated glassware could have been carried out before the study to ensure the most effective nucleated glass was used. This would have increased the likelihood of the true effect of nucleation on drinking rate being investigated.

6.6 Summary

Broadly speaking, results of the studies in this thesis suggest that altering the aesthetics (i.e., volume markings) and structural design (i.e., nucleation) of glassware without changing its shape has limited, if any, effect on consumption. Applying multiple volume markers to curved glasses (Study 5) had a modest slowing effect on the time taken to consume lager. Future research is warranted to investigate if this slowing effect can translate to more naturalistic scenarios such as multiple drinks in a session and/or drinking in groups. Ultimately, this intervention should be assessed in pubs using a similar study design used in Study 1. Assessing the strength of the evidence seen in Study 5, the probability that a detectable difference in monetary takings may be seen is low. Another potential benefit of applying volume markers to glassware could be to improve the pouring accuracy of alcoholic drinks in curved and tulip glasses. CAIs that can affect multiple drinking behaviours may be more cost-effective. Other design alterations such as applying a midpoint marker (Study 4) or adding a nucleation stamp (Studies 6 and 7) appeared to have no meaningful effect on alcohol consumption. The accurate pouring in straight (Studies 2 and 3) and inverted (Study 3) glasses may form the basis of effective CAIs if further research can establishment the relationship between pouring and alcohol consumption. Ultimately, an effective approach could be to combine glassware based CAIs such as straight glasses and volume markers on curved glassware and non-glassware based CAIs in naturalistic environments. This could result in an additive effect that may meaningfully reduce real-world alcohol consumption. CAIs can be a part of a national alcohol strategy that has the potential to reduce excessive population alcohol use and reduce alcohol-related harms.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Almiron-Roig, E., Tsiountsioura, M., Lewis, H. B., Wu, J., Solis-Trapala, I., & Jebb, S. A. (2015). Large portion sizes increase bite size and eating rate in overweight women. *Physiology & Behavior, 139*, 297-302.

Anderson, & Baumberg. (2006). *Alcohol in Europe: a public health perspective: Institute of Alcohol Studies*. Retrieved from http://ec.europa.eu/health/ph_determinants/life_style/alcohol/documents/alcohol_europe.pdf

Anderson, P., Chisholm, D., & Fuhr, D. C. (2009). Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. *The Lancet, 373*(9682), 2234-2246.

Attwood, A. S., Scott-Samuel, N. E., Stothart, G., & Munafò, M. R. (2012). Glass shape influences consumption rate for alcoholic beverages. *PloS One, 7*(8), e43007.

Babor, T., Barbor, T., Caetano, R., & Casswell, S. (2003). *Alcohol and public policy: no ordinary commodity*: Oxford University Press New York.

Bach, P. J., & Schaefer, J. M. (1979). The tempo of country music and the rate of drinking in bars. *Journal of Studies on Alcohol and Drugs, 40*(11), 1058-1059.

Bamforth, C. (2000). Perceptions of beer foam. *Journal of the Institute of Brewing, 106*(4), 229-238.

Bandura, A. (1998). Health promotion from the perspective of social cognitive theory. *Psychology and Health, 13*(4), 623-649.

Banerjee, A., & Duflo, E. (2012). *Poor economics: a radical rethinking of the way to fight global poverty*. New York: Public Affairs.

Bell, R., Meiselman, H. L., Pierson, B. J., & Reeve, W. G. (1994). Effects of adding an Italian theme to a restaurant on the perceived ethnicity, acceptability, and selection of foods. *Appetite, 22*(1), 11-24.

Blumenthal-Barby, J. S., & Burroughs, H. (2012). Seeking better health care outcomes: the ethics of using the “nudge”. *The American Journal of Bioethics, 12*(2), 1-10.

Bohn, M. J., Krahn, D. D., & Staehler, B. A. (1995). Development and initial validation of a measure of drinking urges in abstinent alcoholics. *Alcoholism: Clinical and Experimental Research, 19*(3), 600-606.

Borland, R., Yong, H. H., Wilson, N., Fong, G. T., Hammond, D., Cummings, K. M., Hosking, W., & McNeill, A. (2009). How reactions to cigarette packet health warnings influence quitting: findings from the ITC Four-Country survey. *Addiction, 104*(4), 669-675.

Borsari, B., & Carey, K. B. (2001). Peer influences on college drinking: a review of the research. *Journal of Substance Abuse, 13*(4), 391-424.

Bouchery, E. E., Harwood, H. J., Sacks, J. J., Simon, C. J., & Brewer, R. D. (2011). Economic costs of excessive alcohol consumption in the US, 2006. *American Journal of Preventive Medicine, 41*(5), 516-524.

Bowen, D. J., Kreuter, M., Spring, B., Cofta-Woerpel, L., Linnan, L., Weiner, D., Bakken, S., Kaplan, C. P., Squiers, L., Fabrizio, C., & Fernandez, M. (2009). How we design feasibility studies. *American Journal of Preventive Medicine, 36*(5), 452-457. doi:10.1016/j.amepre.2009.02.002

Brandish, E., & Sheron, N. (2010). Drinking patterns and the risk of serious liver disease. *Expert Review of Gastroenterology & Hepatology, 4*(3), 249-252.

Brennan, A., Meng, Y., Holmes, J., Hill-McManus, D., & Meier, P. S. (2014). Potential benefits of minimum unit pricing for alcohol versus a ban on below cost selling in England 2014: modelling study. *BMJ, 349*, g5452.

British Medical Association. (2008). *Alcohol misuse. Tackling the UK epidemic.* Retrieved from London: http://www.dldocs.stir.ac.uk/documents/Alcoholmisuse.pdf

Cable, N., & Sacker, A. (2008). Typologies of alcohol consumption in adolescence: Predictors and adult outcomes. *Alcohol and Alcoholism, 43*(1), 81-90. doi:10.1093/alcalc/agm146

Caldwell, C., & Hibbert, S. A. (1999). Play that one again: the effect of music tempo on consumer behaviour in a restaurant. *E-European Advances in Consumer Research, 4*, 58-62.

Campbell, G., & Fogarty, J. (2006). The nature of the demand for alcohol: understanding elasticity. *British Food Journal, 108*(4), 316-332.

Carroll, T. (1979). The effect of dissolved nitrogen gas on beer foam and palate. *Technical Quarterly Master Brewers Association of America*.

Carruthers, S. J., & Binns, C. W. (1992). The standard drink and alcohol consumption. *Drug and Alcohol Review, 11*(4), 363-370. doi:10.1080/09595239200185491

Cavazzana, A., Larsson, M., Hoffmann, E., Hummel, T., & Haehner, A. (2017). The vessel's shape influences the smell and taste of cola. *Food Quality and Preference, 59*, 8-13. doi:http://dx.doi.org/10.1016/j.foodqual.2017.01.014

Chait, L., & Griffiths, R. R. (1982). Smoking behavior and tobacco smoke intake: response of smokers to shortened cigarettes. *Clinical Pharmacology & Therapeutics, 32*(1), 90-97.

Chandrashekar, J., Yarmolinsky, D., von Buchholtz, L., Oka, Y., Sly, W., Ryba, N. J., & Zuker, C. S. (2009). The taste of carbonation. *Science, 326*(5951), 443-445.

Chikritzhs, T., Catalonao, P., & Pascal, R. (2009). *Predicting alcohol-related harms from licensed outlet density: a feasibility study.* Retrieved from http://www.nabca.org/assets/Docs/predicting-alcohorelated-harms.pdf

Chisholm, D., Rehm, J., Van Ommeren, M., & Monteiro, M. (2004). Reducing the global burden of hazardous alcohol use: a comparative cost-effectiveness analysis. *Journal of Studies on Alcohol and Drugs, 65*(6), 782-793.

Clark, R., Linforth, R., Bealin-Kelly, F., & Hort, J. (2011). Effects of ethanol, carbonation and hop acids on volatile delivery in a model beer system. *Journal of the Institute of Brewing, 117*(1), 74-81.

Cliff, M. A. (2001). Influence of wine glass shape on perceived aroma and colour intensity in wines. *Journal of Wine Research, 12*(1), 39-46.

Cole, J. (1994). Preventing injuries from bar glasses. Lobby the government for a safety standard. *BMJ, 308*(6938), 1237.

Collins, J. J. (1981). *Drinking and crime: perspectives on the relationship between alcohol consumption and criminal behaviour*: Tavistock Publications.

Cornforth, A. (2009). Behaviour change: insights for environmental policy making from social psychology and behavioural economics. *Policy Quarterly, 5*(4), 21-28.

Cox, W. M., Fadardi, J. S., & Pothos, E. M. (2006). The addiction-stroop test: theoretical considerations and procedural recommendations. *Psychological Bulletin, 132*(3), 443.

DeRicco, D. A. (1978). Effects of peer majority on drinking rate. *Addictive Behaviors, 3*(1), 29-34.

Dericco, D. A., & Garlington, W. K. (1977). The effect of modeling and disclosure of experimenter's intent on drinking rate of college students. *Addictive Behaviors, 2*(2-3), 135-139.

DeRicco, D. A., & Niemann, J. E. (1980). In vivo effects of peer modeling on drinking rate. *Journal of Applied Behavior Analysis, 13*(1), 149-152.

Dessirier, J.-M., Simons, C. T., Carstens, M. I., O'Mahony, M., & Carstens, E. (2000). Psychophysical and neurobiological evidence that the oral sensation elicited by carbonated water is of chemogenic origin. *Chemical Senses, 25*(3), 277-284.

Diepeveen, S., Ling, T., Suhrcke, M., Roland, M., & Marteau, T. M. (2013). Public acceptability of government intervention to change health-related behaviours: a systematic review and narrative synthesis. *BMC Public Health, 13*(1), 756.

Diliberti, N., Bordi, P. L., Conklin, M. T., Roe, L. S., & Rolls, B. J. (2004). Increased portion size leads to increased energy intake in a restaurant meal. *Obesity Research, 12*(3), 562-568. doi:10.1038/oby.2004.64

Donadini, G., Fumi, M. D., & Faveri, M. (2011). How foam appearance influences the Italian consumer's beer perception and preference. *Journal of the Institute of Brewing, 117*(4), 523-533.

Drews, D., Vaughn, D., & Anfiteatro, A. (1992). Beer consumption as a function of music and the presence of others. *Journal of the Pennsylvania Academy of Science, 65*, 134-136.

Dunkel, A., & Hofmann, T. (2010). Carbonic anhydrase IV mediates the fizz of carbonated beverages. *Angewandte Chemie International Edition, 49*(17), 2975-2977.

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence, 97*(1–2), 1-20. doi:https://doi.org/10.1016/j.drugalcdep.2008.03.030

Field, M., Duka, T., Eastwood, B., Child, R., Santarcangelo, M., & Gayton, M. (2007). Experimental manipulation of attentional biases in heavy drinkers: do the effects generalise? *Psychopharmacology, 192*(4), 593-608. doi:10.1007/s00213-007-0760-9

Field, M., & Eastwood, B. (2005). Experimental manipulation of attentional bias increases the motivation to drink alcohol. *Psychopharmacology, 183*(3), 350-357. doi:10.1007/s00213-005-0202-5

Ford, A. L., Bergh, C., Södersten, P., Sabin, M. A., Hollinghurst, S., Hunt, L. P., & Shield, J. P. H. (2010). Treatment of childhood obesity by retraining eating behaviour: randomised controlled trial. *BMJ, 340*. doi:10.1136/bmj.b5388

Forsyth, A. J. M. (2008). Banning glassware from nightclubs in Glasgow (Scotland): observed impacts, compliance and patron's views. *Alcohol and Alcoholism, 43*(1), 111-117. doi:10.1093/alcalc/agm142

Gallet, C. A. (2007). The demand for alcohol: a meta-analysis of elasticities. *Australian Journal of Agricultural and Resource Economics, 51*(2), 121-135. doi:10.1111/j.1467-8489.2007.00365.x

Gates, P., Copeland, J., Stevenson, R. J., & Dillon, P. (2007). The influence of product packaging on young people's palatability rating for RTDs and other alcoholic beverages. *Alcohol and Alcoholism, 42*(2), 138-142.

Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: an integrative review of implicit and explicit attitude change. *Psychological Bulletin, 132*(5), 692-731. doi:10.1037/0033-2909.132.5.692

Gill, J. S., & Donaghy, M. (2004). Variation in the alcohol content of a 'drink' of wine and spirit poured by a sample of the Scottish population. *Health Education Research, 19*(5), 485-491.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *Journal of Personality and Social Psychology, 74*(6), 1464.

Greenwald, A. G., Poehlman, T. A., Uhlmann, E. L., & Banaji, M. R. (2009). Understanding and using the Implicit Association Test: III. Meta-analysis of predictive validity. *Journal of Personality and Social Psychology, 97*(1), 17.

Guéguen, N., Hélène, L. G., & Jacob, C. (2004). Sound level of background music and alcohol consumption: an empirical evaluation. *Perceptual and Motor Skills, 99*(1), 34-38.

Guéguen, N., Jacob, C., Le Guellec, H., Morineau, T., & Lourel, M. (2008). Sound level of environmental music and drinking behavior: a field experiment with beer drinkers. *Alcoholism: Clinical and Experimental Research, 32*(10), 1795-1798.

Hammond, D. (2011). Health warning messages on tobacco products: a review. *Tobacco Control, 20*(5), 327-337.

Hammond, D., Fong, G. T., McDonald, P. W., Cameron, R., & Brown, K. S. (2003). Impact of the graphic Canadian warning labels on adult smoking behaviour. *Tobacco Control, 12*(4), 391-395.

Health and Social Care Information Centre. (2016). *Adult alcohol consumption*. Retrieved from http://content.digital.nhs.uk/catalogue/PUB22610/HSE2015-Adult-alc.pdf

Herring, R., Thom, B., Foster, J., Franey, C., & Salazar, C. (2008). Local responses to the Alcohol Licensing Act 2003: the case of Greater London. *Drugs: Education, Prevention and Policy, 15*(3), 251-265. doi:10.1080/09687630801920641

HM Government. (2007). *Safe. Sensible. Social. The next steps in the national alcohol strategy*. Retrieved from http://webarchive.nationalarchives.gov.uk/20130123192107/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_075218

HM Government. (2012). *The government's alcohol strategy*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224075/alcohol-strategy.pdf

Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: a theoretical framework and empirical review. *Health Psychology Review, 2*(2), 111-137. doi:10.1080/17437190802617668

Holden, C., Hawkins, B., & McCambridge, J. (2012). Cleavages and co-operation in the UK alcohol industry: a qualitative study. *BMC Public Health, 12*(1), 483.

Hollands, G., Shemilt, I., Marteau, T., Jebb, S., Kelly, M., Nakamura, R., Suhrcke, M., & Ogilvie, D. (2013). Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. *BMC Public Health, 13*(1), 1218.

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Lewis, H. B., Wei, Y., Higgins, J., & Ogilvie, D. (2015). Portion, package or tableware size for changing selection and consumption of food, alcohol and tobacco. *Cochrane Database of Systematic Reviews*, Issue 9. Art. No.: CD011045. doi: 10.1002/14651858.CD011045.pub2.

Hollands, J., & Dyre, B. P. (2000). Bias in proportion judgments: the cyclical power model. *Psychological Review, 107*(3), 500.

Holmberg, L. (1975). The influence of elongation on the perception of volume of geometrically simple objects. *Psychological Research Bulletin, 15*(2), 1-18.

Hughes, K., Quigg, Z., Bellis, M. A., Calafat, A., Hasselt, N. v., Kosir, M., Voorham, L., Goossens, F. X., Duch, M., & Juan, M. (2012). Drunk and disorganised: relationships between bar characteristics and customer intoxication in european drinking environments. *International Journal of Environmental Research and Public Health, 9*(11), 4068.

Hughes, K., Quigg, Z., Eckley, L., Bellis, M., Jones, L., Calafat, A., Kosir, M., & van Hasselt, N. (2011). Environmental factors in drinking venues and alcohol-related harm: the evidence base for European intervention. *Addiction, 106 Suppl 1*, 37-46. doi:10.1111/j.1360-0443.2010.03316.x

Hummel, T., Delwiche, J., Schmidt, C., & Hüttenbrink, K.-B. (2003). Effects of the form of glasses on the perception of wine flavors: a study in untrained subjects. *Appetite, 41*(2), 197-202.

Jeffery, R. W., French, S. A., Raether, C., & Baxter, J. E. (1994). An environmental intervention to increase fruit and salad purchases in a cafeteria. *Preventive Medicine, 23*(6), 788-792. doi:http://dx.doi.org/10.1006/pmed.1994.1135

Jones, A., Button, E., Rose, A. K., Robinson, E., Christiansen, P., Di Lemma, L., & Field, M. (2016). The ad-libitum alcohol 'taste test': secondary analyses of potential confounds and construct validity. *Psychopharmacology, 233*(5), 917-924.

Jones, A., Guerrieri, R., Fernie, G., Cole, J., Goudie, A., & Field, M. (2011). The effects of priming restrained versus disinhibited behaviour on alcohol-seeking in social drinkers. *Drug and Alcohol Dependence, 113*(1), 55-61. doi:http://dx.doi.org/10.1016/j.drugalcdep.2010.07.006

Kerr, J., Eves, F., & Carroll, D. (2000). Posters can prompt less active people to use the stairs. *Journal of Epidemiology & Community Health, 54*(12), 942-943.

Kerr, W. C., Patterson, D., Koenen, M. A., & Greenfield, T. K. (2009). Large drinks are no mistake: Glass size, not shape, affects alcoholic beverage drink pours. *Drug and Alcohol Review, 28*(4), 360-365. doi:10.1111/j.1465-3362.2009.00056.x

Kersbergen, I., & Field, M. (2017). Alcohol consumers' attention to warning labels and brand information on alcohol packaging: Findings from cross-sectional and experimental studies. *BMC Public Health, 17*(1), 123. doi:10.1186/s12889-017-4055-8

Kesman, R., Ebbert, J., Harris, K., & Schroeder, D. (2011). Portion control for the treatment of obesity in the primary care setting. *BMC Research Notes, 4*(1), 346.

Kleemann, A., Albrecht, J., Schöpf, V., Haegler, K., Kopietz, R., Hempel, J., Linn, J., Flanagin, V., Fesl, G., & Wiesmann, M. (2009). Trigeminal perception is necessary to localize odors. *Physiology & Behavior, 97*(3), 401-405.

Knai, C., Petticrew, M., Durand, M. A., Eastmure, E., & Mays, N. (2015). Are the public health responsibility deal alcohol pledges likely to improve public health? An evidence synthesis. *Addiction, 110*(8), 1232-1246. doi:10.1111/add.12855

Kosin, P., Savel, J., Evans, D., & Broz, A. (2012). How the method of beer dispense influences the served CO2 content and the sensory profile of beer. *Journal of the American Society of Brewing Chemists, 70*(2), 103.

Lawless, H. T., Bender, S., Oman, C., & Pelletier, C. (2003). Gender, age, vessel size, cup vs. straw sipping, and sequence effects on sip volume. *Dysphagia, 18*(3), 196-202.

Leffingwell, T. R., Cooney, N. J., Murphy, J. G., Luczak, S., Rosen, G., Dougherty, D. M., & Barnett, N. P. (2013). Continuous objective monitoring of alcohol use: twenty-first century measurement using transdermal sensors. *Alcoholism: Clinical and Experimental Research, 37*(1), 16-22. doi:10.1111/j.1530-0277.2012.01869.x

Lemmens, P. H. (1994). The alcohol content of self-report and standard drinks. *Addiction, 89*(5), 593-601. doi:10.1111/j.1360-0443.1994.tb03336.x

Lewis, R. (2009). InBev improves Stella's chalice glass. *Publican's Morning Advertiser.* Retrieved from http://www.morningadvertiser.co.uk/content/view/print/436475

Licensing Act. (2003). Retrieved from http://www.legislation.gov.uk/ukpga/2003/17/contents

Liger-Belair, G. (2005). The physics and chemistry behind the bubbling properties of Champagne and sparkling wines: a state-of-the-art review. *Journal of Agricultural and Food Chemistry, 53*(8), 2788-2802.

Liger-Belair, G., Conreux, A., Villaume, S., & Cilindre, C. (2013). Monitoring the losses of dissolved carbon dioxide from laser-etched champagne glasses. *Food Research International, 54*(1), 516-522.

Liger-Belair, G., Polidori, G., & Jeandet, P. (2008). Recent advances in the science of champagne bubbles. *Chemical Society Reviews, 37*(11), 2490-2511.

Luke, L., Dewar, C., Bailey, M., McGreevy, D., Morris, H., & Burdett-Smith, P. (2002). A little nightclub medicine: the healthcare implications of clubbing. *Emergency Medicine Journal, 19*(6), 542-545.

Maas, J., de Ridder, D. T., de Vet, E., & De Wit, J. B. (2012). Do distant foods decrease intake? The effect of food accessibility on consumption. *Psychology & Health, 27*(sup2), 59-73.

Machin, D., Campbell, M. J., Fayers, P. M., & Pinol, A. (1997). *Sample size tables for clinical studies* (2nd ed.). Oxford: Blackwell Science Ltd.

Malouff, J., Schutte, N., Wiener, K., Brancazio, C., & Fish, D. (1993). Important characteristics of warning displays on alcohol containers. *Journal of Studies on Alcohol and Drugs, 54*(4), 457-461.

Marteau, T. M., Hollands, G. J., & Fletcher, P. C. (2012). Changing human behavior to prevent disease: the importance of targeting automatic processes. *Science, 337*(6101), 1492-1495.

McCambridge, J., Hawkins, B., & Holden, C. (2014). The challenge corporate lobbying poses to reducing society's alcohol problems: insights from UK evidence on minimum unit pricing. *Addiction, 109*(2), 199-205.

McElrea, H., & Standing, L. (1992). Fast music causes fast drinking. *Perceptual and Motor Skills, 75*(2), 362-362.

McFarland, B. (2001). Marketing your wine offering. *Publican's Morning Advertiser.* Retrieved from http://www.morningadvertiser.co.uk/content/view/print/511191

McFarland, B. (2002). A glass of their own. *Publican's Morning Advertiser* Retrieved from https://www.morningadvertiser.co.uk/Article/2002/09/20/A-glass-of-their-own

Meilgaard, M. C. (1982). Prediction of flavor differences between beers from their chemical composition. *Journal of Agricultural and Food Chemistry, 30*(6), 1009-1017.

Meusel, T., Negoias, S., Scheibe, M., & Hummel, T. (2010). Topographical differences in distribution and responsiveness of trigeminal sensitivity within the human nasal mucosa. *Pain, 151*(2), 516-521.

Michie, S., van Stralen, M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation Science, 6*(1), 42.

Mirabito, A., Oliphant, M., Van Doorn, G., Watson, S., & Spence, C. (2017). Glass shape influences the flavour of beer. *Food Quality and Preference, 62*, 257-261. doi:http://dx.doi.org/10.1016/j.foodqual.2017.05.009

North, A. C. (2012). The effect of background music on the taste of wine. *British Journal of Psychology, 103*(3), 293-301. doi:10.1111/j.2044-8295.2011.02072.x

North, A. C., Shilcock, A., & Hargreaves, D. J. (2003). The effect of musical style on restaurant customers' spending. *Environment and Behavior, 35*(5), 712-718. doi:doi:10.1177/0013916503254749

Nosek, B. A., & Banaji, M. R. (2001). The go/no-go association task. *Social Cognition, 19*(6), 625-666.

O'Keefe, J. H., Bhatti, S. K., Bajwa, A., DiNicolantonio, J. J., & Lavie, C. J. (2014). Alcohol and cardiovascular health: The dose makes the poison…or the remedy. *Mayo Clinic Proceedings, 89*(3), 382-393. doi:https://doi.org/10.1016/j.mayocp.2013.11.005

Ono, M., Hashimoto, S., Kakudo, Y., Nagami, K., & Kumada, J. (1983). Foaming and beer flavor. *Journal of the American Society of Brewing Chemists, 41*, 19-23.

Papies, E. K., & Hamstra, P. (2010). Goal priming and eating behavior: enhancing self-regulation by environmental cues. *Health Psychology, 29*(4), 384.

Patrick, M. E., Wray-Lake, L., Finlay, A. K., & Maggs, J. L. (2010). The long arm of expectancies: adolescent alcohol expectancies predict adult alcohol use. *Alcohol and Alcoholism, 45*(1), 17-24. doi:10.1093/alcalc/agp066

Pechey, R., Attwood, A. S., Couturier, D.-L., Munafò, M. R., Scott-Samuel, N. E., Woods, A., & Marteau, T. M. (2015). Does glass size and shape influence judgements of the volume of wine? *PloS One, 10*(12), e0144536.

Pechey, R., Couturier, D.-L., Hollands, G. J., Mantzari, E., Munafò, M. R., & Marteau, T. M. (2016). Does wine glass size influence sales for on-site consumption? A multiple treatment reversal design. *BMC Public Health, 16*(1), 390. doi:10.1186/s12889-016-3068-z

Pedersen, S. D., Kang, J., & Kline, G. A. (2007). Portion control plate for weight loss in obese patients with type 2 diabetes mellitus: a controlled clinical trial. *Archives of Internal Medicine, 167*(12), 1277-1283.

Piaget, J. (1967). Cognitions and conservations: two views. *Contemporary Psychology, 12*(11), 532-533.

Piaget, J. (1968). Quantification, conservation, and nativism. *Science, 162*(3857), 976-979.

Piaget, J. (1969). *The mechanisms of perception*. London: Routledge & Kegan.

Plant, M., Plant, M., & Thornton, C. (2002). People and places: some factors in the alcohol-violence link. *Journal of Substance Use, 7*(4), 207-213.

Prins, A. (1998). *Foam formation in beer: some physics behind it.* Paper presented at the Monograph-European Brewery Convention.

Priser, C., Etiévant, P. X., Nicklaus, S., & Brun, O. (1997). Representative champagne wine extracts for gas chromatography olfactometry analysis. *Journal of Agricultural and Food Chemistry, 45*(9), 3511-3514.

Prochaska, J., & Diclemente, C. (1983). Stages and processes of self-change of smoking: toward an integrative model of change. *Journal of Consulting and Clinical Psychology, 51*, 390-395.

Quain, D. (2007). *Draught beer quality-challenges and opportunities.* Paper presented at the Proceedings of the 31st Congress. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.604.6134&rep=rep1&type=pdf.

Raghubir, P., & Krishna, A. (1999). Vital dimensions in volume perception: can the eye fool the stomach? *Journal of Marketing Research*, 313-326.

Raudenbush, B., Meyer, B., Eppich, W., Corley, N., & Petterson, S. (2002). Ratings of pleasantness and intensity for beverages served in containers congruent and incongruent with expectancy. *Perceptual and Motor Skills, 94*(2), 671-674. doi:doi:10.2466/pms.2002.94.2.671

Rehm, J., Baliunas, D., Borges, G. L., Graham, K., Irving, H., Kehoe, T., Parry, C. D., Patra, J., Popova, S., & Poznyak, V. (2010). The relation between different dimensions of alcohol consumption and burden of disease: an overview. *Addiction, 105*(5), 817-843.

Reich, R. R., Below, M. C., & Goldman, M. S. (2010). Explicit and implicit measures of expectancy and related alcohol cognitions: a meta-analytic comparison. *Psychology of Addictive Behaviors, 24*(1), 13-25. doi:10.1037/a0016556

Reinoso Carvalho, F., Wang, Q., Van Ee, R., & Spence, C. (2016). The influence of soundscapes on the perception and evaluation of beers. *Food Quality and Preference, 52*, 32-41. doi:http://doi.org/10.1016/j.foodqual.2016.03.009

Robinson, E., Oldham, M., Cuckson, I., Brunstrom, J. M., Rogers, P. J., & Hardman, C. A. (2016). Visual exposure to large and small portion sizes and perceptions of portion size normality: three experimental studies. *Appetite, 98*, 28-34.

Rolls, B. J., Roe, L. S., Meengs, J. S., & Wall, D. E. (2004). Increasing the portion size of a sandwich increases energy intake. *Journal of the American Dietetic Association, 104*(3), 367-372.

Rozin, P., Scott, S., Dingley, M., Urbanek, J. K., Jiang, H., & Kaltenbach, M. (2011). Nudge to nobesity I: minor changes in accessibility decrease food intake. *Judgment and Decision Making, 6*(4), 323.

Ruhm, C. J. (2012). Understanding overeating and obesity. *Journal of Health Economics, 31*(6), 781-796.

Saunders, J. B., Aasland, O. G., Babor, T. F., de la Fuente, J. R., & Grant, M. (1993). Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction, 88*(6), 791-804.

Schifferstein, H. N. J. (2009). The drinking experience: cup or content? *Food Quality and Preference, 20*(3), 268-276. doi:http://dx.doi.org/10.1016/j.foodqual.2008.11.003

Schlauch, R. C., Christensen, R. L., Derrick, J. L., Crane, C. A., & Collins, R. L. (2015). Individual differences in approach and avoidance inclinations moderate the effect of self-control depletion on ad-lib drinking. *Alcoholism: Clinical and Experimental Research, 39*(12), 2480-2488. doi:10.1111/acer.12915

Shafer, N. E., & Zare, R. N. (1991). Through a beer glass darkly. *Physics Today, 44*(10), 48-52.

Shafir, E., Simonson, I., & Tversky, A. (2006). A behavioural perspective on consumer protection. *Competition and Consumer Law Journal, 15*(3), 302-317.

Sheeran, P., Gollwitzer, P. M., & Bargh, J. A. (2013). Nonconscious processes and health. *Health Psychology, 32*(5), 460.

Sheeran, P., Harris, P., & Epton, T. (2011). Does making people think they are at risk, or making them feel afraid or worried, change their behaviour? A meta-analysis of the experimental evidence. *Unpublished manuscript, University of Sheffield, Sheffield, United Kingdom*.

Shepherd, J. (1994). Preventing injuries from bar glasses. *BMJ, 308*(6934), 932.

Sherman, J. W., Gawronski, B., & Trope, Y. (2014). *Dual-process theories of the social mind*. New York: Guilford Publications.

Shields, A. L., Guttmannova, K., & Caruso, J. C. (2004). An examination of the factor structure of the Alcohol Use Disorders Identification Test in two high-risk samples. *Substance Use and Misuse, 39*(7), 1161-1182.

Smith, E. R., & DeCoster, J. (2000). Dual-process models in social and cognitive psychology: conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review, 4*(2), 108-131. doi: 10.1207/S15327957PSPR0402_01

Spence, C., Velasco, C., & Knoeferle, K. (2014). A large sample study on the influence of the multisensory environment on the wine drinking experience. *Flavour, 3*(1), 8.

Stead, M., Angus, K., Macdonald, L., & Bauld, L. (2014). Looking into the glass: glassware as an alcohol marketing tool, and the implications for policy. *Alcohol and Alcoholism, 49*(3), 317-320. doi:10.1093/alcalc/agt178

Stockley, C. S. (2001). The effectiveness of strategies such as health warning labels to reduce alcohol-related harms—an Australian perspective. *International Journal of Drug Policy, 12*(2), 153-166.

Stockwell, T. (2006). *A review of research into the impacts of alcohol warning labels on attitudes and behaviour*. Retrieved from https://dspace.library.uvic.ca/bitstream/handle/1828/4785/Alcohol%20Warning%20Labels%202006.pdf?sequence=1&isAllowed=y

Stockwell, T., & Stirling, L. (1989). Estimating alcohol content of drinks: common errors in applying the unit system. *BMJ, 298*(6673), 571-572. doi:10.1136/bmj.298.6673.571-a

Stockwell, T., Zhao, J., Martin, G., Macdonald, S., Vallance, K., Treno, A., Ponicki, W., Tu, A., & Buxton, J. (2013). Minimum alcohol prices and outlet densities in British Columbia, Canada: estimated impacts on alcohol-attributable hospital admissions. *American Journal of Public Health, 103*(11), 2014-2020.

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*(3), 220-247.

Swift, R. (2003). Direct measurement of alcohol and its metabolites. *Addiction, 98*(2), 73-80.

Thaler, R., & Sunstein, C. (2008). *Nudge: improving decisions about health, wealth, and happiness*: Yale University Press.

Thaler, R. H., & Benartzi, S. (2004). Save more tomorrow™: using behavioral economics to increase employee saving. *Journal of Political Economy, 112*(S1), S164-S187.

Thomsen, S. R., & Fulton, K. (2007). Adolescents' attention to responsibility messages in magazine alcohol advertisements: An eye-tracking approach. *Journal of Adolescent Health, 41*(1), 27-34.

Tominaga, T., Guimbertau, G., & Dubourdieu, D. (2003). Role of certain volatile thiols in the bouquet of aged Champagne wines. *Journal of Agricultural and Food Chemistry, 51*(4), 1016-1020.

Troy, D. M., Attwood, A. S., Maynard, O. M., Scott-Samuel, N. E., Hickman, M., Marteau, T. M., & Munafò, M. R. (2017). Effect of glass markings on drinking rate in social alcohol drinkers. *The European Journal of Public Health, 27*(2), 352-356.

Troy, D. M., Maynard, O. M., Hickman, M., Attwood, A. S., & Munafò, M. R. (2015). The effect of glass shape on alcohol consumption in a naturalistic setting: a feasibility study. *Pilot and Feasibility Studies,* 1:27.

Turner, C. (1990). How much alcohol is in a standard drink - an analysis of 125 studies. *British Journal of Addiction, 85*(9), 1171-1175.

Turney, E. (2009). AB InBev: volume down, market share up in UK. *Publican's Morning Advertiser.* Retrieved from http://www.morningadvertiser.co.uk/content/view/print/434764

Van der Vorst, H., Engels, R. C., Meeus, W., & Deković, M. (2006). Parental attachment, parental control, and early development of alcohol use: a longitudinal study. *Psychology of Addictive Behaviors, 20*(2), 107.

Van Kleef, E., Otten, K., & van Trijp, H. C. (2012). Healthy snacks at the checkout counter: a lab and field study on the impact of shelf arrangement and assortment structure on consumer choices. *BMC Public Health, 12*(1), 1072.

Varey, C. A., Mellers, B. A., & Birnbaum, M. H. (1990). Judgments of proportions. *Journal of Experimental Psychology: Human Perception and Performance, 16*(3), 613.

Velasco, C., Jones, R., King, S., & Spence, C. (2013). Assessing the influence of the multisensory environment on the whisky drinking experience. *Flavour, 2*(1), 23.

Wagenaar, Salois, & Komro. (2009). Effects of beverage alcohol price and tax levels on drinking: a meta-analysis of 1003 estimates from 112 studies. *Addiction, 104*(2), 179-190.

Wagenaar, A. C., & Toomey, T. L. (2000). Alcohol policy: gaps between legislative action and current research. *Contemporary Drug Problems, 27*(4), 681-733. doi:doi:10.1177/009145090002700402

Walker, D., Smarandescu, L., & Wansink, B. (2014). Half full or empty: cues that lead wine drinkers to unintentionally overpour. *Substance Use & Misuse, 49*(3), 295-302.

Wan, X., Zhou, X., Woods, A. T., & Spence, C. (2015). Influence of the glassware on the perception of alcoholic drinks. *Food Quality and Preference, 44*, 101-110. doi:http://dx.doi.org/10.1016/j.foodqual.2015.03.018

Wang, Q., & Spence, C. (2015a). Assessing the effect of musical congruency on wine tasting in a live performance setting. *i-Perception, 6*(3). doi:https://doi.org/10.1177/2041669515593027

Wang, Q. J., & Spence, C. (2015b). Assessing the influence of the multisensory atmosphere on the taste of vodka. *Beverages, 1*(3), 204-217.

Wansink, B., Cardello, A. V., & North, J. (2005). Fluid consumption and the potential role of canteen shape in minimizing dehydration. *Military Medicine, 170*(10), 871-873.

Wansink, B., & Ittersum, K. (2005). Shape of glass and amount of alcohol poured: comparative study of effect of practice and concentration. *BMJ, 331*, 1512. doi:10.1136/bmj.331.7531.1512

Wansink, B., & Van Ittersum, K. (2003). Bottoms up! The influence of elongation on pouring and consumption volume. *Journal of Consumer Research, 30*(3), 455-463.

Warburton, A. L., & Shepherd, J. P. (2000). Effectiveness of toughened glassware in terms of reducing injury in bars: a randomised controlled trial. *Injury Prevention, 6*(1), 36-40.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070.

Weafer, J., & Fillmore, M. T. (2008). Individual differences in acute alcohol impairment of inhibitory control predict ad libitum alcohol consumption. *Psychopharmacology, 201*(3), 315-324. doi:10.1007/s00213-008-1284-7

Webb, G., Shakeshaft, A., Sanson-Fisher, R., & Havard, A. (2009). A systematic review of work-place interventions for alcohol-related problems. *Addiction, 104*(3), 365-377. doi:10.1111/j.1360-0443.2008.02472.x

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin, 132*(2), 249.

White, A. M., Kraus, C. L., McCracken, L. A., & Swartzwelder, H. S. (2003). Do college students drink more than they think? Use of a free-pour paradigm to determine how college students define standard drinks. *Alcoholism: Clinical and Experimental Research, 27*(11), 1750-1756.

Wilkinson, C., Allsop, S., Cail, D., Chikritzhs, T., Daube, M., Kirby, G., & Mattick, R. (2014). *Alcohol warning labels: evidence of effectiveness on risky alcohol consumption and short term outcomes*. Retrieved from http://www.foodstandards.govt.nz/code/applications/documents/Alcohol-warning-labels-report-1.pdf

Wilkinson, C., & Room, R. (2009). Warnings on alcohol containers and advertisements: international experience and evidence on effects. *Drug and Alcohol Review, 28*(4), 426-435. doi:10.1111/j.1465-3362.2009.00055.x

Williams, R., Aspinall, R., Bellis, M., Camps-Walsh, G., Cramp, M., Dhawan, A., Ferguson, J., Forton, D., Foster, G., Gilmore, I., Hickman, M., Hudson, M., Kelly, D., Langford, A., Lombard, M., Longworth, L., Martin, N., Moriarty, K., Newsome, P., O'Grady, J., Pryke, R., Rutter, H., Ryder, S., Sheron, N., & Smith, T. (2014). Addressing liver disease in the UK: a blueprint for attaining excellence in health care and reducing premature mortality from lifestyle issues of excess consumption of alcohol, obesity, and viral hepatitis. *Lancet, 384*(9958), 1953-1997. doi:10.1016/s0140-6736(14)61838-9

World Health Organisation. (2009). *Evidence for the effectiveness and cost-effectiveness of interventions to reduce alcohol-related harm*. Retrieved from http://apps.who.int/iris/bitstream/10665/107269/1/E92823.pdf

World Health Organisation. (2012). *European action plan to reduce the harmful use of alcohol 2012–2020*. Retrieved from http://apps.who.int/iris/bitstream/10665/107307/1/E96726.pdf

World Health Organisation. (2013). *Global strategy to reduce the harmful use of alcohol*. Retrieved from http://www.who.int/substance_abuse/msbalcstragegy.pdf

World Health Organisation. (2014). *Global status report on alcohol and health*. Retrieved from http://apps.who.int/iris/bitstream/10665/112736/1/9789240692763_eng.pdf

Zhao, J., Stockwell, T., Martin, G., Macdonald, S., Vallance, K., Treno, A., Ponicki, W. R., Tu, A., & Buxton, J. (2013). The relationship between minimum alcohol prices, outlet densities and alcohol-attributable deaths in British Columbia, 2002–09. *Addiction, 108*(6), 1059-1069.

Zupan, Z., Pechey, R., Couturier, D. L., Hollands, G. J., & Marteau, T. M. (2017). Micro-drinking behaviours and consumption of wine in different wine glass sizes: a laboratory study. *BMC Psychology, 5*(1), 17. doi:10.1186/s40359-017-0183-2